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The Pennsylvania Woodcock Management Study

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The Pennsylvania Woodcock Management Study

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COVER PHOTO BY BOB PARLAMAN

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INTRODUCTION

THE American woodcock (*Philohela minor*) interests many people. The upland bird hunter finds it a very sporting target, and the bird watcher or casual outdoorsman is intrigued by its peculiar habits. Although approximately 12,000 woodcock are now (1950-1960) taken by Pennsylvania hunters during the fall season, these birds are less abundant than in former years. A ten (10) year study was initiated in 1951 to determine why woodcock numbers had declined and what could be done to remedy the situation.

Earlier woodcock investigations in Pennsylvania and elsewhere were limited primarily to the bird itself. These studies were and still are extremely important. More recent surveys dealt with factors limiting woodcock populations, and present Pennsylvania research placed emphasis on woodcock management techniques. In addition to habitat management research, it also was necessary to conduct limited studies on life history, ecology and populations.

Primary objectives of the project were:

(1) To ascertain woodcock abundance and distribution in Pennsylvania.
(2) To determine woodcock habitat requirements.
(3) To devise techniques for creating and improving woodcock habitat.
(4) To study effects of hunting and other limiting factors on woodcock populations.

ACKNOWLEDGMENTS

THIS project was conducted under the Federal Aid to Wildlife Restoration Act of 1937 and designated as Pittman-Robertson Project 50-R (Woodcock Management Study). Actual field work was conducted from 1951 to 1961. It was supervised indirectly by the U. S. Fish and Wildlife Service but mainly by the Pennsylvania Game Commission. Direct supervision was given by former Chiefs of the Division of Research, Pennsylvania Game Commission. These were Dr. Roger M. Latham, Glenn L. Bowers and Harvey A. Roberts.

Sincere thanks are extended to the many individuals and organizations who assisted with the project. Much credit is due Dr. Latham, who initiated the project and followed it closely to its conclusion. His inspiration and patient guidance were a constant source of assurance.

Permission to conduct habitat development experiments in the Stone Valley Experimental Forest was grateful received from Dr. Maurice K. Goddard, then Head of the Department of Forestry, Pennsylvania State University. Forestry Professors W. C. Bramble and O. A. Schmidt of the same faculty gave assistance in this phase of the project.

Grateful appreciation for counsel and encouragement is expressed to Dr. W. M. Sharp, former Leader of the Pennsylvania Cooperative Wildlife Research Unit, and to the late Dr. P. F. English, former professor of Wildlife Management at Pennsylvania State University.

Within the Pennsylvania Game Commission thanks are given to biologists of the Division of Research and members of the Divisions of Land Management and Law Enforcement who assisted on many occasions.

Interested sportsmen donated much time and energy to the project. Outstanding among these were J. W. Taylor, of Lewistown, Steve Laputka, of Freeland, and Harold Henry, of Pine Grove Mills. Special gratitude is extended to Carl Rice, of Sunbury, who provided a good bird dog to aid in the work. Many others assisted in collecting census and kill data, in recording hunting success, and in making numerous field observations. All are to be commended for their contributions.

Thanks are given to those landowners who permitted work on their property, and to other individuals who cooperated in various ways.

Credit also is given to those who assisted in reviewing and editing the manuscript, namely, Merle H. Markley and Harvey A. Roberts.

Study Methods

GENERAL

Study Site Selection

THE PRIMARY study areas, located in Centre, Huntingdon, Indiana, Luzerne, and Erie Counties, were chosen because of known utilization by woodcock or experimental management possibilities. A study area 25 miles long and one-half mile wide in the Bald Eagle Valley, Centre County, was used primarily for intensive studies of populations, harvests, and environmental factors. Sites in other counties were used mainly for experimental habitat management. Additional information on cover preferences, populations and harvest trends was collected throughout the Commonwealth.

Sex and Age Determination

The sex of woodcock was determined by measuring the length of the bill—a technique developed by Tufts (1940) and Mendall and Aldous (1943). The wear pattern on the tips of the barbs of the primary wing feathers—a technique described by Sheldon, Greeley and Kupa (1958)—was used during the hunting season to differentiate between juvenile and adult birds.

Censusing

A spring census technique for woodcock was initiated in Maine about 1940. The technique was first described by Mendall and Aldous (1943), and since that time improvements have been made by other investigators. This modified procedure was used throughout the study to determine trends in the woodcock breeding population.

Forty individuals cooperated in making the census in Pennsylvania from 1952 to 1959. One-third of these were Game Commission personnel; some individuals censused more than one route. Instructions were given to each census taker after a suitable area was located in the vicinity of his headquarters.

Trapping

It was necessary to capture and mark a number of birds in order to gain information concerning movements of resident woodcock. Techniques for making single captures of males on the singing grounds were developed by Norris, Beule and Studholme (1940) and improved by Sheldon (1955), but no satisfactory method existed for making multiple catches of both sexes during the summer and fall months. New methods were explored since the above techniques were inadequate and very time consuming.

Experimenting with modifications of the shore bird trap designed by Low (1935), the writer developed a trap which gave the desired results. The technique of building and using the trap to capture woodcock and grouse is described by Liscinsky and Bailey (1955). Since that time Sheldon (1960) perfected a method of mist-netting woodcock in summer.

Approximately one-half of the woodcock banded during the study was captured with the modified shore bird trap. An additional 40 percent was banded as chicks. A few birds also were captured on singing grounds using Sheldon's method (1955).

Use of Drugs

One phase of the woodcock investigation was to involve transfer of woodcock from Louisiana to Pennsylvania. Capture and shipment by air was to have taken place just before the north-

PRIMARY WING TIP width and barb tip wear differentiate males, females, adults and juveniles.

ern migration. The birds were to have been kept in captivity for about a month, then released near known breeding grounds. The experiment was to determine if a local population could be quickly increased by restricting additional female woodcock (by wing feather plucking) to known mating fields.

One problem encountered was that of keeping woodcock alive in small containers for prolonged (24-48 hour) periods. Death, apparently due to stress, occurred within a few hours after capture. It soon became evident that some form of sedation was necessary.

With the cooperation of the U. S. Fish and Wildlife Service and assistance of L. L. Glasgow, Assistant Professor of Game Management, Louisiana State University, and Dr. R. F. Gentry, Veterinarian in charge of Poultry Disease Research, Pennsylvania State University, a series of tests was conducted in an attempt to alleviate the problem. Species used to test drugs included domestic chickens, bobwhite quail and woodcock. Five tranquilizing drugs and one sedative-hypnotic drug were used. These were Serpasil, Thorazine, Compazine, Sparine, Methylpromazine, Trilafon and Noludar.

Intraperitoneal or intramuscular injections were employed. Results are given under "Transplantation" in the section on woodcock management.

Food Habits

A series of feeding tests was conducted on captive woodcock held for testing tranquilizing drugs. Data were collected on the quantity and quality of food eaten, the manner in which various foods were ingested, preference for several probing mediums (soil types) and other feeding characteristics.

Woodcock were held in a 12- x 24-foot pen. To prevent bird injury, the ceiling and sides were lined with cloth netting. Six boxes (4 x 18 x 18 inches), designed to hold earthworms, were embedded in the floor of the pen. Three units of 2 boxes each contained different types of soil.

Another independent structure, a "feeding chamber" (1 x 3 x 4 feet), was built at one end of the pen. This net-covered compartment was used to confine individual woodcock when it was desired to make observations of individual woodcock while feeding. This was done through a peephole.

Detailed records were kept on the quality and quantity of food eaten. Daily counts of probe holes were made in each soil sample. To facilitate probe counting, soils were kept moist and probe holes obliterated following each tally.

Habitat Analysis

Woodcock habitat data were collected by several methods which varied with the purpose of the particular survey. In one instance hunters were asked to record data throughout the state. A simple daily record form was provided as shown in Appendix A. The hunter recorded the number of woodcock flushed and killed in various broad cover type categories. Several other minor questions were included.

An intensive analysis of the vegetative composition of woodcock habitats was made. Studies of specific cover types involved data collection on plant composition, stem growth and stand development, earthworm abundance, soil properties, and woodcock utilization. Floral data consisted of species occurrence and percent cover. Sample stems were measured and counted for growth characteristics. The number and volume of earthworms per unit sample were determined by digging or by the use of a potassium permanganate solution. Two gallons of the solution (⅜ oz. $KMnO_4$ in 2 gallons of water) were poured over a square yard of soil surface after all vegetation was sheared off. Miller (1957) describes techniques for analyzing soil properties not covered in this study. The field data form used for this study is shown in the Appendix B. Earthworms from each sampling were preserved and later identified by Dr. W. R. Murchie, Assistant Professor of Zoology, University of Michigan.

Habitat Manipulation

Four methods of manipulating woodcock habitat were tested. These included planting, cutting, spraying, and grazing. A brief description of each is given below. Experiments were conducted on the Stone Valley Experimental Forest, the Conemaugh Reservoir Area, State Game Lands 187, and on several privately owned lands.

Planting experiments involved both seedlings and direct seeding. Seedling stock was selected from that available at the Game Commission nursery. No alder seeds or seedlings were available from any commercial source. It

FEEDING HABITS of captive woodcock were observed and photographed by the author.

PREFERRED NATURAL foods included night crawlers, garden worms and meal worms.

DURING THE OBSERVATIONS, live worms were the most readily taken of the items presented for consumption.

ADULT BIRDS were banded after being captured in a modified shore bird trap.

was necessary to collect seed and propagate seedlings at the nursery.

A wide variety of sites, in potentially good woodcock environment, was selected for the planting experiments. Row and group plantings of different widths and sizes were tested. Results from direct seeding of alder were determined by sowing alder seed in cultivated and uncultivated plots at approximately two-week intervals throughout the year.

Clear cutting, release cutting, and thinning were employed. Clear cutting, or the complete severance of all woody stems, was used to create singing grounds and to rejuvenate alder and aspen stands. Release cutting was employed in coverts heavily invaded by large trees. The overstory of large trees was removed to allow shrubs and small trees to dominate the site. Extensive and exceptionally dense coverts were thinned by removing individual stems and groups of stems.

Power saws and other hand cutting tools were used in the felling and limbing operations. Tractors were used to remove commercial wood from the study area.

Herbicide spraying tests on vegetation were on foliage, on the basal portion of the stem, and on cut stumps. Foliage spraying was limited primarily to herbaceous vegetation, whereas stump and basal spraying was employed on woody plants. Basal spraying was used to thin stands and to release more desirable trees and shrubs. Stump sprays were used exclusively to prevent sprouting.

A number of formulations and concentrations of 2,4-D and 2,4,5-T were used. Methods of application varied. Details are given under the management section. A knapsack type sprayer generally was used to apply chemical agents. A truck-mounted 50-gallon sprayer was employed on accessible study areas.

Effects of cattle grazing in woodcock cover were studied by interviewing farmers and making observations. One 16-acre area, previously ungrazed for 10 years, was established as a special study area. Records were kept on grazing intensity, vegetational changes, and woodcock use.

Harvest Measurements

Numbers of woodcock bagged and hunting pressure were measured by bag checks in special study areas, questionnaires, and by Game Protectors' estimates. Hunters throughout the state, primarily interested in grouse and woodcock, were asked to record hours hunted and number of woodcock bagged. A form (see Appendix A) was provided for this purpose. Personal contacts and interviews were important in obtaining complete data for intensively studied areas.

Life History

GENERAL

MANAGEMENT of any game species demands a thorough understanding of the animal in its natural environment. A knowledge of its capacity to reproduce and survive, the manner and extent to which it moves about, the food it eats, and the habitat it occupies are of prime importance to the manager. The following discussion covers some of these features as they pertain to woodcock in Pennsylvania.

SPRING MIGRATION

Woodcock were observed arriving as early as February 23 in southern Pennsylvania, February 27 in the central part, and March 3 in northern Pennsylvania. Most woodcock, however, do not reach the state until the last half of March. Migration to and through Pennsylvania is completed by the second week of April.

COURTSHIP AND BREEDING

The Breeding Season

The woodcock breeding season takes place over a comparatively long period. Based on nesting studies and from direct observations, the breeding season in Pennsylvania extends from the first week in March to the third week in May. The male actively solicits the attention of the female from the time of his arrival on the singing grounds until most woodcock chicks are full grown. By mid-May, courtship actively dwindles rapidly, and observations of courtship behavior after June 1 were very uncommon.

The Singing Grounds

Woodcock courtship and breeding activity centers around the so-called "singing ground." The singing ground is simply a tree and shrub-free clearing. Although these clearings are basically herbaceous openings in forests or brushland, woodcock were observed using a wide variety of sites. These included roadways, pastures, cultivated fields, baseball diamonds, lawns, and garden plots.

Great variation in the size and shape of singing fields was noted. Display sites were of practically any shape and ranged in size upwards from 100 square feet. Very often several woodcock simultaneously used a large field, especially if it was broken up by clumps of shrubs or hedgerows.

This indicates a wide range in singing ground characteristics, but certain requirements were essential to all. Regardless of site or size, singing fields were located in territory providing the breeding population with suitable food and cover.

Courtship Behavior

The courtship display, adequately described by many writers including Mendall and Aldous (1943) and Pettingill (1936), is indeed spectacular. In brief, performances consist of spiraling flights, made at dawn and at dusk, to a height of several hundred feet. During a flight of about one minute duration, which begins and ends at a particular clearing, the male emits characteristic sounds with his voice and wings. Thus the female is attracted to the site, and mating ensues.

Detailed studies of woodcock on the breeding or singing sites were not an objective of this study. Only those observations made incidental to other duties are presented. These pertain mostly to untimely or unusual courtship displays.

On several occasions during early March, woodcock were observed "singing" when there was a foot or two of snow on the ground. Once, when the temperature was 15° F. and the snow was so crusted it would support an average man, a woodcock was observed courting as vigorously as in warm weather. On another occasion a fellow biologist watched a woodcock singing on January 3, 1955, near Dover, Del. The ground surface was frozen and the air temperature was 25° F. Another observation of unseasonable activity was made on October 15, 1955, in central Pennsylvania. Although it was raining and the temperature 35° F., a woodcock was observed performing on the edge of a marsh.

NESTING

The Nesting Season

Field data, gathered over a seven-year period (1953-1959), show that woodcock in Pennsylvania have a rather long nesting season. Hatching data on 45 nests are presented in Table 1. Hatching was observed from April 5 to June 14, with the peak occurring during the last week in April. Seventy percent of the hatch occurred during the last two weeks in April and the first week of May. By back-dating the earliest hatching date, it was calculated that incubation of one clutch began on March 15 and that egg laying started on March 11.

TABLE 1

Woodcock Hatching Dates in Pennsylvania (1953-1959)

Date:		Number of Hatches	Percent of Total Hatches
Month	Week		
April	1st	1	2
	2nd	5	11
	3rd	7	16
	4th	17	38
May	1st	7	16
	2nd	5	11
	3rd	2	4
	4th	—	—
June	2nd	1	2
Total		45	100

The Nesting Site

Woodcock nesting site requirements are few. They prefer to nest on the ground in the edges of small trees or shrub thickets, but will use a wide variety of cover types and sites. Atypically, woodcock were found nesting in old fields with no overhead woody plant cover and in young mixed hardwood stands 50 feet tall. Their nests were occasionally found in bottomlands adjacent to small streams, but woodcock appeared to prefer higher ground as nesting sites.

The occurrence of woody plants at woodcock nest sites is presented in Table 2. Based on data collected at 54 nest sites in central Pennsylvania, hawthorn and crab apple occurred most frequently. Alder, gray dogwood, aspen, elm, and maple also occurred quite frequently. These plants occurred both in pure stands and also in mixtures. The average height of nesting cover was 12 feet.

Size of Clutch

Woodcock ordinarily laid 4 eggs per clutch. Clutches of 5 were rare, but nests containing 2 or 3 eggs were not uncommon. Small clutches generally occurred late in the nesting season and possibly indicated re-nesting attempts. Observations on 54 nests revealed an average clutch size of 3.69 eggs.

Incubation Period

Previous investigators found that the woodcock incubation period varied from 19 to 22 days. The exact incubation time for two nests was recorded in this study. Details are as follows: On April 9, 1954, at 9 p.m., a woodcock hen was flushed from a

TABLE 2

Occurrence of Woody Plants at 54 Woodcock Nesting Sites in Central Pennsylvania

Plant Species*	Occurrence: Number	Occurrence: Percent
Hawthorn	23	42
Crab Apple	18	33
Elm	10	18
Alder	9	16
Aspen	9	16
Maple	9	16
Gray Dogwood	8	15
White Pine	7	13
Hickory	6	11
Blackberry	6	11
Oak	5	9
Black Cherry	3	5
Willow	3	5
Choke Cherry	2	4
Ash	2	4
Blue Beech	2	4
Black-haw Viburnum	2	4
Spiraea	2	4
Silky Dogwood	1	2
Spicebush	1	2
Larch	1	2
Locust	1	2
Sumac	1	2

**See Appendix C for scientific names.*

nest containing 3 eggs. At 3 p.m., the same day the nest held 4 eggs. Twenty-one days later (April 30) the eggs hatched. A second nest with one egg was located on April 9, 1955. Not until April 11, when 4 eggs were present did the woodcock begin to spend full time on the nest. Twenty-one days later four woodcock chicks were hatched.

Nesting Success

When compared to many other game birds, woodcock have a rather high degree of nesting success. As shown in Table 3, one or more eggs hatched in 30 of 54 nests for a nesting success of 56 percent. In total, 199 eggs were under observation. Of this number, 100 (50 percent) hatched. Since some nesting failures could be attributed to disturbance by the investigator, normal nesting success is probably higher.

Woodcock nest losses can be attributed to many causes, including predation, disturbance by humans and domestic animals, and failure of the embryo to completely develop.

During this study data were collected on 30 woodcock nests which experienced loss (Table 4). Losses included 13 (43 percent) to predation, 13 (43 percent) to desertion, and 4 (14 percent) to unknown causes. It also is of interest that 16 (53 percent) of the losses occurred during early stages of incubation, 5 (17 percent) during the middle stages and 9 (30 percent) just prior to hatching.

JUVENAL WOODCOCK

Brood Size

Woodcock nesting studies involved observations on 38 broods. Most broods contained 3 or 4 chicks, but broods of only 1 or 2 were not uncommon. The average brood size was 3.03 chicks. Brood size data are presented in Table 5.

Mortality of juvenile woodcock was difficult to ascertain. The average number of eggs hatched per successful nest was 3.33 and the brood size was 3.03; therefore a 9 percent loss was indicated. The difference between age ratios at brood time and fall hunting season indicated a loss of 15 percent.

TABLE 3

Woodcock Nesting Success Data—Pennsylvania (1953-1959)

Number of nests observed	—	54
Number of successful nests*	—	30
Percentage of successful nests	—	56
Total number of eggs in nests	—	199
Total number of eggs hatched	—	100
Percentage of eggs hatched	—	50

**Considered successful if one or more eggs hatched.*

TABLE 4

Data on Woodcock Nest Losses—Pennsylvania (1953-1959)

Cause of Loss:		Number of Nests:
1. Predation		13 (43%)
(a) Mammalian (raccoon, skunk, house cat)	10	
(b) Avian (sharp-shinned hawk killed hen)*	1	
(c) Other	2	
2. Desertion		13 (43%)
(a) Due to interference by man and/or dog	7	
(b) Due to incomplete development of embryos**	6	
3. Unknown		4 (14%)
Stage of Incubation when Losses Occurred:		
1. Early incubation		16 (53%)
2. Mid-incubation		5 (17%)
3. Late incubation		9 (30%)
Original number of eggs in 30 nests	109	
Number of eggs lost from 30 nests	99	

**Accipiter striatus.*

***In a few nests a portion hatched.*

Rate of Growth

Woodcock chicks undergo rapid body and feather development as reflected in a study of mandible measurements. A day-old chick's bill measured ½ inch, and by the time it could fly (12-14 days) its bill measured 1¾ inches. At 3 weeks young woodcock can fly well and at one month of age are difficult to tell from the parent.

Parental Relationship

Woodcock chicks experience a short relationship with their female parent. As soon as the natal down dries, the young leave the nest. They have no difficulty in moving through vegetation at this early stage. Broods were observed to move up to 200 feet from the nest in one day. As a general rule, however, most woodcock broods stayed within 100 feet of the nesting site for the first few days. The group remains together as a family unit until the chicks are well-developed. It was not uncommon to flush a family group in June. After this, however, family groups lost their identity.

The role of the female in feeding her chicks has often been discussed. In this respect the investigator had an interesting experience. Two eggs from a deserted nest were placed in an incubator and within a few days both hatched. When the chicks were about 48 hours old, earthworms were dangled in front of them. Without hesitation they reached forward and began to eat the worms. On the third day, one chick ate four worms each of which was approximately two inches long. Unfortunately the chicks did not live long enough to conduct additional tests.

TABLE 5

Woodcock Brood Size Data—Pennsylvania (1953-1959)

Brood Size (No. of Chicks)	No. of Broods Observed	Total No. Chicks
4	13	52
3	15	45
2	8	16
1	2	2
Total:	38	115

Average Brood size 3.03

ADULT WOODCOCK

Weights and Measurements

A small portion of the study was devoted to the collection of weight, sex, and age data. The information on sex and age is given elsewhere.

A discussion of the weight data follows. One hundred and sixty-six woodcock (87 males and 79 females) were weighed over several hunting seasons. The length of the bill as described by Tufts (1940) was used as the criterion for sex identification. To verify the accuracy of this technique, the sex of 123 woodcock was determined by internal examination. The bill measurement reflected the true sex in all but one bird.

Weights of males ranged from 135 to 182 grams and averaged 158 grams (5.6 oz.). The weight of females ranged from 163 to 232 grams and averaged 199 grams (7.0 oz.). In the aggregate, weights ranged from 135 grams (4.7 oz.) to 232 grams (8.2 oz.) and averaged 176 grams (6.2 oz.). A summary of woodcock weights by sex in 10-day periods during the hunting season is given in Table 6. The data show not only the range and average weights by sex, but also the progression of weight increase as the season advanced.

TABLE 6

Woodcock Weights by Sex in 10-day Periods During the Hunting Season

Period	Number Weighed	Average (g.) Weight	Weight (g.) Range
		Males	
Oct. 1-10	22	152	135-174
Oct. 11-21	21	152	142-182
Oct. 22-31	34	163	136-173
Nov. 1-10	10	165	149-176
Total	87	158 (5.6 oz.)	135-182 (4.7 oz.-6.4 oz.)
		Females	
Oct. 1-10	29	189	163-207
Oct. 11-21	14	194	177-205
Oct. 22-31	25	202	182-231
Nov. 1-10	11	209	186-232
Total	79	199 (6.2 oz.)	163-232 (5.7 oz.-8.2 oz.)

Longevity

Records for Pennsylvania show that only two woodcock were recovered two years after banding. All other band recoveries were from birds marked for less than one year (details on capturing and banding appear in the Appendix). From Massachusetts, where many woodcock were banded, Sheldon (1955) reported "one bird was captured four successive years, seven have been captured in their third spring, and twenty-eight birds for two years in a row." Blankenship (1957) computed an average life span of 10.6 months for woodcock from the U. S. Fish and Wildlife Service banding records.

Movements

From 1939 to 1960, 239 woodcock were banded in Pennsylvania, of which 204 were banded during the recent investigation. To date, 48 bands have been recovered. Trapping and shooting resulted in 27 and 21 recoveries, respectively. Six banded birds were recaptured once; three banded woodcock were shot outside the state. During this same period five woodcock banded in other states were bagged in Pennsylvania.

Recovery of 47 bands indicated that 26 birds moved less than a few hundred yards from the original banding site, 12 went approximately one mile, 3 traveled two miles, 2 moved five miles, and one each traveled 7, 8, 35

TABLE 7

Woodcock banded and recovered in Pennsylvania (1939 to 1960)

Band	Original Capture		First Recovery				Second Recovery:				Time Lapse:**	
Number	Date	Place County***	Date	Place County	**** Method	Distance* (Miles)	Date	Place County	Method	Distance* (Miles)	(Yrs.)	(Days)
39-425001	4/17/39	1	10/21/40	4	1	80.00					1	188
513-83302	7/17/52	1	10/28/52	1	1	.25						103
513-83303	7/24/52	1	10/18/52	1	1	.25						86
513-83305	7/27/52	1	10/ 6/53	1	2	5.50					1	71
513-83310	8/ 8/52	1	10/26/53	1	1	5.25					1	80
513-83341	4/29/53	1	8/11/53	1	2	.75	10/17/53	1	2	.25		182
513-83347	4/29/53	1	7/21/53	1	2	.50	8/ 5/53	1	2	0		101
513-83352	7/28/53	1	10/26/53	1	1	.25						90
513-83355	8/ 5/53	1	10/12/53	1	2	0						99
513-83360	8/20/53	1	8/22/53	1	2	.25						2
513-83361	8/22/53	1	8/24/53	1	2	0	10/ 3/53	1	1	2.00		43
513-83363	8/24/53	1	9/28/53	1	2	.25	10/12/53	1	2	0		48
513-83365	9/27/53	1	10/13/53	1	2	0						16
513-83367	9/29/53	1	10/ 4/53	1	2	.25	10/26/53	1	2	0		29
513-83378	10/11/53	1	11/10/53	1	2	0	11/21/53	1	2	0		41
553-39031	6/29/54	1	10/ 8/54	3	1	35.00						101
513-83395	7/13/54	1	7/26/55	1	2	0						13
513-83396	7/13/54	1	7/31/54	1	2	.25						18
553-39001	7/27/54	1	7/28/54	1	2	0						1
513-83400	7/27/54	1	10/28/54	1	1	0						91

TABLE 7 (continued)

Woodcock banded and recovered in Pennsylvania (1939 to 1960)

Band Number	Original Capture		First Recovery				Second Recovery:				Time Lapse:**	
	Date	Place County***	Date	Place County	**** Method	Distance* (Miles)	Date	Place County	Method	Distance* (Miles)	(Yrs.)	(Days)
553-39004	7/29/54	1	8/11/55	1	2	0					1	13
553-39006	8/ 2/54	1	11/ 6/54	1	1	0						95
553-39007	10/ 1/54	1	10/24/54	1	1	7.00						23
553-39062	4/30/55	1	10/15/55	1	1	.50						167
553-39043	7/27/55	1	10/15/55	1	1	2.50						170
553-39026	7/ 6/55	1	7/15/55	1	2	0						9
553-39047	7/18/55	1	8/11/55	1	2	0						24
553-39046	7/18/55	1	10/18/55	1	1	.25						91
553-39045	7/15/55	1	7/25/55	1	2	0						10
553-39048	7/21/55	1	7/24/55	1	2	0	11/ 5/55	1	1	8.00		107
553-39050	7/22/55	1	7/26/55	1	2	0	8/ 2/55	1	2	0		10
553-39019	8/ 3/55	1	8/ 6/55	1	2	0	8/ 9/55	1	2	0		6
553-39018	8/ 3/55	1	10/12/55	1	1	2.50						70
553-39022	8/10/55	1	8/20/55	1	2	0						10
553-39025	9/15/55	1	9/19/55	1	2	0						4
553-39027	9/21/55	1	10/29/55	1	1	0						39
553-39086	4/30/56	1	10/ 9/56	1	1	0						131
553-39079	9/ 1/60	2	10/17/60	2	1	0						46

*—*Recovery distance is from point of previous capture.*

**—*Time lapse is from original capture to last recovery.*

***—*County: (1) Centre (2) Huntingdon (3) Clinton (4) Clarion.*

****—*Method: (1) Shot (2) Trap.*

TABLE 8

Additional Data on Banded Woodcock

Band Number	Original Capture:				Recovery:				Time Lapse:	
	Date	State	County	Locale	Date	State	County	Locale	Yrs.	Days
Woodcock Banded in Pennsylvania and Recovered Elsewhere										
513-83341	4/29/53	Pa.	Centre	"Barrens"	2/11/54	South Carolina	Colleton	Cottageville		300
39-425044	4/ 8/40	Pa.	Centre	"Barrens"	11/ 5/40	Conn.		Redding		212
39-425017	5/ 8/39	Pa.	Centre	"Barrens"	12/27/40	Miss.		Vicksburg	1	236
Woodcock Banded Elsewhere and Recovered in Pennsylvania										
37-320840	5/10/41	Maine	Washington	Baring	10/24/41	Pa.	Clarion	Chase Mills		167
41-304313	2/ 3/41	La.	Iberville	Grosse Tere	10/21/41	Pa.	McKean			264
49-362640	1/ 3/52	La.	Iberville	Sunshine	10/18/52	Pa.	McKean	Turtle Point		289
523-93280	1/ 2/54	La.	Landry	Swayze	10/30/54	Pa.	Warren	Grand Valley		302
523-94722	12/28/53	La.	St. Charles	Bonnett Spillway	11/11/59	Pa.	Schuylkill	Sacramento	5	318

Note: All above recoveries are from woodcock shot during hunting seasons, except #513-83341. This bird assumed killed by a house cat.

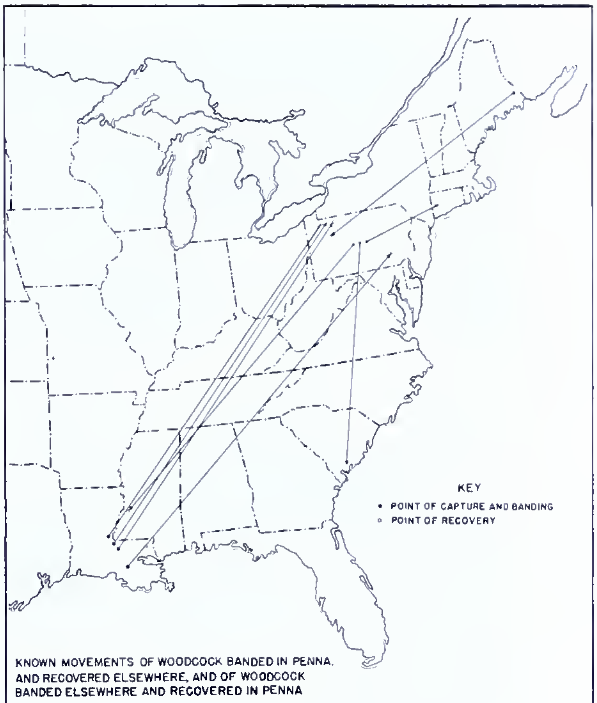
and 80 miles. Details are included in Tables 7 and 8 and Figures 1 and 2. Additional banding information also is given in Appendix D.

FOODS AND FEEDING

Numerous investigators have reported that earthworms constitute a major portion of the woodcock's diet, including Sperry (1940), Mendall and Aldous (1943), and Miller (1957). However, much is yet unknown concerning the various earthworm species and their relationship to woodcock and woodcock habitat. The possible importance of foods other than earthworms needs additional research. Non-earthworm foods might be especially valuable during dry seasons.

Food Consumed

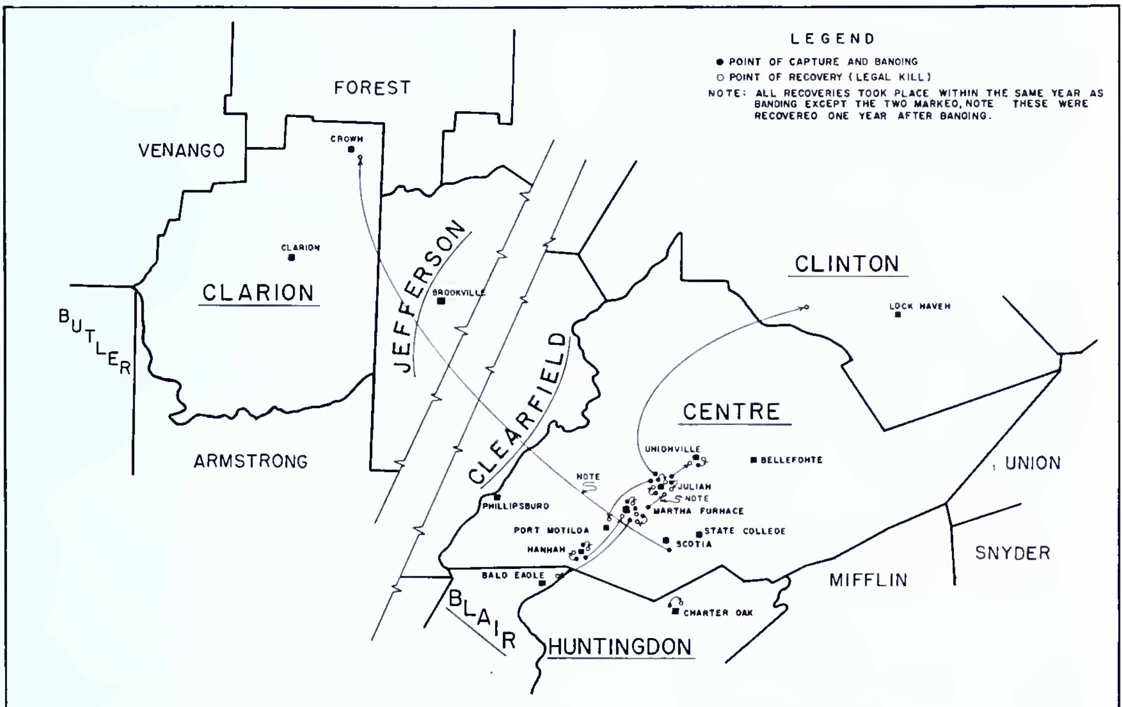
The daylight feeding habits of captive woodcock made possible accurate observation of the birds' reaction to a



KNOWN MOVEMENTS OF WOODCOCK BANDED IN PENNA. AND RECOVERED ELSEWHERE, AND OF WOODCOCK BANDED ELSEWHERE AND RECOVERED IN PENNA

1939 TO 1960

Fig. 1



KNOWN MOVEMENTS OF WOODCOCK WITHIN PENNSYLVANIA

1939 TO 1960

Fig. 2

variety of foods. Preferred foods included night crawlers, garden worms, meal worms, fly larvae, small grasshoppers and slivers of raw deer liver, deer steak, fish, and luncheon meat. The quantity of food available and the amount consumed are presented in Table 9. Over a five-day experimental period, daily food consumption by each of two birds averaged 72 percent, or 58 grams of the 80 grams available.

TABLE 9

Food of Two Woodcock During Five Days in Captivity

Food Given	Number Given	Number Ingested
Night Crawlers	65	46
Garden Worms	520	470
Fly Larvae	180	150
Meal Worms	125	110
Grasshoppers*	30	18
Deer Liver*	17	13
Deer Steak*	10	6
Luncheon Meat*	10	10
Fish Fillet*	5	0

**See text.*

The woodcock's reaction to various food is of interest. Live earthworms were always the most readily eaten. Sometimes larger worms were taken first, other times the smaller. Dead earthworms were ingested. Fly larvae and meal worms were readily accepted when earthworms were not available. Although occasionally attempts were made to eat winged grasshoppers, woodcock would not eat them unless the wings were removed. The slivers of meat were seldom taken unless they were placed in a shallow (⅛ inch deep) pool of water. Apparently water kept the slivers soft and worm-like. Slivers of fish were never eaten or picked up by woodcock.

To facilitate record keeping on earthworms consumed by woodcock in various tests, a number were weighed and measured. Three species readily available were night crawlers (*Lumbricus* spp.), garden worms and red worms (both *Helodrilus* spp.). Data on earthworm weights and measurements are presented in Table 10.

TABLE 10

Average Length, Volume, and Weight of Earthworms

Earthworm Species	Per single specimen (average)			
	Length: (inches)	Volume: (cc.)	Weight: (g.)	(oz.)
Night Crawler	4-6	4.80	4.6	.16
Garden Worm	3-5	.68	.7	.03
Red Worm	2-4	.47	.5	.02

Analyses of nutrient composition of earthworms were made by C. E. French et al (1957), Department of Animal Nutrition, Pennsylvania State University. The three species used were: *Lumbricus terrestris, Lumbricus rubellus,* and *Eisenia rosea.*

Results shown in Tables 11 and 12 indicate that all three species were very high in protein content, containing from 53 to 64 percent on a dry basis. They also contained appreciable amounts of fat and energy. While low in carbohydrates, earthworms contained large amounts of ash. The latter is partly due to ingested soil particles, although the worms had been scoured overnight in damp paper towels.

Many observers, including the writer, have noted that woodcock can eat their own weight in food during a 24-hour period. A few also have reported that woodcock can eat twice their weight during that time. However, woodcock can be kept alive and in good condition on approximately one-half their body weight in food intake daily.

During 12 days in captivity, two woodcock were offered 2,452 grams (5 lb., 6 oz.) of earthworms. Sixty percent (1,352 grams or 2 lb. 13 oz.) of the earthworms were ingested. This amounted to 60 grams (2.1 oz.) per bird per day. The range in the amount

TABLE 11

Weight, Volume and Dry Matter Content of Earthworm Samples

Species	Volume	Weight Fresh	Weight Dry	Dry Matter	Moisture
	ml.	g.	g.	%	%
L. terrestris	220	227.7	39.57	17.38	82.62
L. rubellus	265	258.7	42.18	16.30	83.69
E. rosea	260	247.0	40.47	16.38	83.61

of earthworms eaten daily was from 9 to 105 grams (.3-3.7 oz.) per bird. The weight loss experienced by the two birds was exactly 29 percent each. At the end of the 12-day test period, the birds were released in the wild. They flew away in normal fashion, apparently none the worse for their experience. For detailed information on this experiment refer to Tables 13 and 14 and Figure 3.

While the two woodcock mentioned previously were supplied with all the worms they could eat, two additional birds were subjected to drastically reduced diets (approximately 20 grams per bird per day). Three days after being placed on the restricted diet both birds died. They experienced weight losses of 40 and 42 percent of the original body weight.

On the basis of the foregoing data, woodcock apparently can be adequately nourished with a daily food intake equal to one-half their body weight. A number of factors influenced the quantity of food eaten in these tests. Under more suitable conditions, captive woodcock would probably eat greater quantities. With a regular diet of approximately three ounces of earthworms daily, it is believed that woodcock could be sustained over long periods with little loss in weight or vigor.

It is interesting to note the probable cost of feeding captive woodcock. The wholesale price of earthworms during the study was approximately $1.60 per pound. A feeding rate of 3 ounces of earthworms daily would cost 30 cents per bird per day. It may be possible to substitute a less expensive food (such as spaghetti, ground or sliced meat, dog food, etc.) and reduce this cost. Project time and facilities did not permit further experiments.

Feeding Habits

One study problem dealt with direct observations on feeding behavior. Fortunately woodcock adapted rapidly to captivity and showed little fear of observers, even in broad daylight. Par-

TABLE 12

Analysis of Earthworms Dry Matter Basis

Species	Protein	Ash	Fat	Carbohydrate	Energy
	%	%	%	%	Cal./g.
L. terrestris	53.50	23.07	6.01	17.42	4.42
L. rubellus	63.69	15.06	4.77	16.48	4.70
E. rosea	61.38	15.67	4.39	18.56	4.73

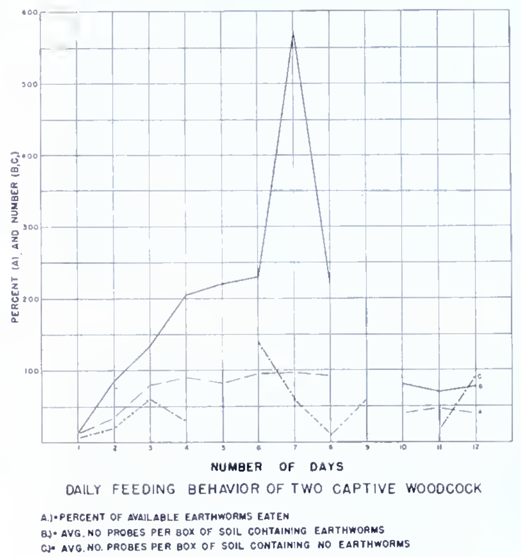


Fig 3

tial concealment permitted close-up observations of woodcock feeding habits.

A description of actual feeding behavior was taken from field notes. “August 4, 1957: 4:00 p.m.: After placing 150 garden worms in and on the soil of the feeding chamber, a woodcock was introduced. Feeding began within three minutes. In the next 5 minutes the bird ate 22 worms, appearing to eat until filled. Indeed, the last few worms dangled from the corners of its mouth until more space permitted further ingestion. In eating the bird selected a worm from the surface or extracted one from within the soil (soil depth 1 to 1½ inches), straightened the worm out in its bill, using a foot when necessary, and quickly swallowed. Occasionally a worm was ingested in a doubled position. The worms were reached or probed for with a slightly opened bill (approximately ⅛ inch). Often the worm was dropped to permit a better alignment for swallowing; namely, end first. Numerous times the woodcock hammered its bill on the bottom of the box, where there was little or no soil, as if to remove excessive soil which had accumulated. While swallowing, the woodcock frequently raised and lowered its body. After stuffing itself, the bird walked about stretching, gently bouncing, ruffling its feathers and then closed its eyes as if asleep.”

TABLE 13

Earthworms Consumed by Two Woodcock During 12 Days of Captivity

	Quantity Consumed		
Species	Number	Weight (g.)	Volume (cc.)
Night Crawler	120	552	576
Garden Worm	704	493	479
Red Worm	814	407	383
Totals:	1,648	1,452	1,438
Average per bird per day:	68	61	60

Evidence gained from this study showed that woodcock can, to a certain extent, detect earthworms in the soil. Table 15 and Figure 4 show that soils containing earthworms were probed about three times as often as those without earthworms. This occurred even when feed boxes were moved to new locations. Most data, however, indicate that trial and error was the usual procedure. In other words, the woodcock probed until it found worms and then concentrated its feeding efforts in these places.

Probing Medium Soil Preference

It has long been suspected that woodcock obtain most of their food from loamy rather than sandy soils. Areas along stream bottoms suitable as woodcock feeding sites are sometimes destroyed by large deposits of sand washed onto the stream banks during floods. When this occurs the earthworm supply is drastically reduced, as is woodcock utilization of the site.

Inherently then, woodcock may refrain from attempting to feed in such soils. This was found to be somewhat true in feeding tests. Whereas only 46 percent of the earthworms placed in sand were utilized, 64 and 71 percent of those placed in clay and loam, respectively, were utilized. Probing was most frequent in clay, next in loam, and least in sand when the soils contained earthworms, but the reverse was true to a lesser extent when the soils contained *no* earthworms. Worms were quite often found dead and broken on the surface of the sand, indicating they were extracted from the soil and left uneaten. These data are recorded in Table 16 and illustrated in Figure 4.

TABLE 14

Weight Losses of Two Woodcock During 12 Days of Captivity

Bird No.	Weight (Grams) on First Day	Last Day	Loss (Grams)	% Loss
1	181	128	53	29%
2	148	104	44	29%
Total	329	232	97	29%

FALL MIGRATION

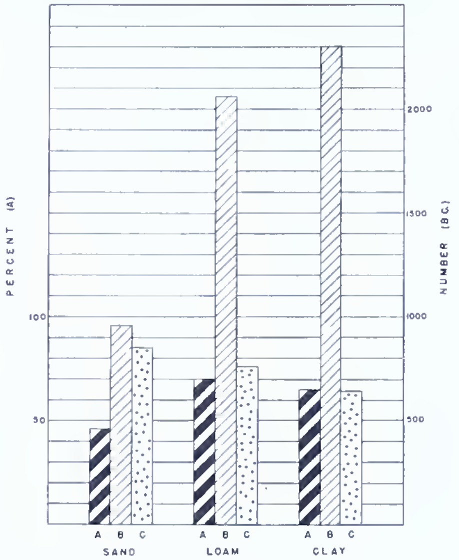
Fall movements of woodcock to their wintering grounds are subject to much conjecture. This can be attributed, in part, to the paucity of data on woodcock behavior at this time of year. Many people have speculated as to the time and direction of migrations, a method to distinguish "flight" birds from resident woodcock, the sex and age composition of migrant flocks, and many other aspects of migration. Some progress is being made, and the following data are submitted.

A "flight" is interpreted to be a group (10 or more birds) migrating from some distant point, and not a local movement or concentration of resident birds. How is the one distinguished from the other? After years

TABLE 15

Feeding Behavior of Two Captive Woodcock in Soil Samples Containing (1) Earthworms and (2) No Earthworms

	Number of Probe Holes in Boxes of Soil (1) Containing Earthworms			(2) Containing No Earthworms					
Day	Boxes	Probes	Probes per Box	Boxes	Probes	Probes per Box	Weight (g.) of Earthworms Placed	Weight (g.) of Earthworms Utilized	Percent of Earthworms Utilized
1	3	19	6	3	5	2	138	18	13
2	3	259	86	3	48	16	376	124	33
3	3	400	133	3	196	65	138	106	77
4	3	607	202	3	88	29	138	129	93
5	6	1287	215	0	0	0	132	109	82
6	1	231	231	5	729	146	210	207	99
7	1	560	560	5	288	58	210	209	99
8	5	1043	209	1	8	8	150	144	96
9	0	0	0	6	364	61	0	0	0
10	6	464	77	0	0	0	360	148	41
11	3	215	71	3	51	17	300	136	45
12	3	225	75	3	266	89	300	123	41
Totals	37	5310	144	35	2043	58	2452	1453	59%



CAPTIVE WOODCOCK FEEDING BEHAVIOR ON THREE TYPES OF SOIL

A - PERCENT OF AVAILABLE EARTHWORMS EATEN
B - NUMBER OF PROBINGS IN SOIL CONTAINING EARTHWORMS
C - NUMBER OF PROBINGS IN SOIL NOT CONTAINING EARTHWORMS

Fig. 4

of field observations and review of research literature, no way was found to distinguish a flight woodcock from a resident bird by either plumage, weight, or flight characteristics.

It seems more reasonable to discern this difference by the location in which the birds are found. Although flight birds often stop to rest in coverts used by resident woodcock, they are just as likely to use areas not inhabited by local birds. These "lighting" spots may be in odd places such as woodlots, conifer plantations, cornfields, and other places where resident woodcock are seldom, if ever, observed. Knowledge of resident woodcock activities throughout the seasons is necessary to make these interpretations.

The belief that local woodcock "move out" before the "flights" arrive is another basis for argument. To shed some light on this, some resident woodcock were captured and banded. Subsequent returns showed that resident woodcock were bagged throughout the hunting season, some as late as November 5. Most birds were killed within a few hundred yards of the point of capture; the longest recorded

TABLE 16

Captive Woodcock Feeding Behavior and Food Utilization in Three Soil Types

Soil Type		Number of Probe Holes:	Weight (g.) of Earthworms 1. Placed:	Weight (g.) of Earthworms 2. Eaten:	Percent Earthworms Eaten	No. of Tests
	Containing:					
Sand	1. Earthworms	979	624	287	46%	11
	2. No Earthworms	847	—	—	—	13
	Total:	1826	—	—	—	24
	Containing:					
Loam	1. Earthworms	2027	864	613	71%	13
	2. No Earthworms	754	—	—	—	11
	Total:	2781	—	—	—	24
	Containing:					
Clay	1. Earthworms	2304	864	552	64%	13
	2. No Earthworms	641	—	—	—	11
	Total:	2945	—	—	—	24

IN THE FEEDING TESTS a higher percentage of earthworms placed in clay and loamy soils were utilized when compared to earthworms placed in sandy soils. Woodcocks probed most frequently in clay, next in loam and least in sand.

movement was eight miles. This data substantiates the earlier findings of Mendall and Aldous (1943).

When, then, do the local movements and big flights occur in Pennsylvania? Within recent years, at least, the major move occurred during the last week in October or the first week in November. Indeed, the largest group of migrating woodcock was observed relatively late in the season—November 7, 1955. A flight of approximately 200 woodcock was encountered by a veteran hunter in northwestern Pennsylvania on that day. Within the next few days smaller groups were flushed by other hunters and a biologist, thereby confirming the fact that a major migration was underway there. On the other hand, local movements of summer and fall residents were sporadic over the years. Occasionally some resident stock, especially in the northern tier counties, move to new locations by relatively short flights earlier in October. Hunters finding these woodcock often assume the "big flights" have arrived. About mid-November woodcock become increasingly scarce, and by November 24-25 fall movement out of the state is complete for both local and migrant birds.

Factors Affecting Abundance and Distribution

GENERAL

A GAME MANAGER must not only have some knowledge of the life history of the species to be managed but also must be acquainted with factors limiting its abundance and distribution. Such matters as reproductive capacity, habitat requirements, and the effects of hunting, weather and other decimating factors must be considered. Many such factors, as they relate to woodcock, were investigated.

REPRODUCTION

The rate at which a species recruits new members through reproduction limits abundance. For woodcock this rate or capacity is comparatively low.

Sex and Age Ratios

Seasonal changes in sex and age ratios are commonly used to determine population turnover. Until recently this technique had limited use with woodcock since there was no suitable method for determining ages of large samples. Since 1958, however, a wing examination technique has been employed quite successfully to separate immature from adult birds. Data from 1,590 wings collected during the hunting season in Pennsylvania over a 3-year period are presented in Table 17. The data reveal an average adult sex ratio of 73 males per 100 females and an adult-immature ratio of 1:1.

Life Equation

When all information on gains and losses occurring in a population is not available it is helpful to construct a life equation table. After listing factors that can be measured it is often possible to interpolate the unknown values with reasonable accuracy. Such an approach shows the proportional causes of gains and losses. A life equation for a stable population of woodcock is given below in Table 18. Except for the fall sex and age ratios, which represent a statewide sample, data used in the table were collected in the Bald Eagle Valley Study area.

HABITAT

Basic Needs

Woodcock use a number of rather well-defined cover types and a few basic essentials must be present in each. No single factor of environmental makeup can be used as the criterion. Broadly speaking, good woodcock habitat should contain the following characteristics:

1. The predominant vegetation (shrubs and small trees) should be less than 30 years old.
2. The density of the overstory and ground cover should be approximately 75 and 25 percent, respectively.
3. The soil beneath or near the covert should be a type that maintains a rather constant supply of preferred woodcock food.

These requirements are most commonly met in areas recently retired from cultivation, in drained swamplands, and on recently burned or cutover sites. Whenever one or more of these characteristics is missing, woodcock frequently move to more favorable coverts. Sometimes, and in some areas, changing weather conditions have a direct bearing on habitat conditions. Conversely, the better locations provide adequate environment to sustain woodcock throughout the spring, summer and fall. Details of these qualities follow.

Vegetational Composition

This term refers to the various plant species occurring within woodcock habitat. The most intensive study of this kind was made in the Bald Eagle Valley study area. Data recorded at 62 sites inhabited by woodcock are presented in Table 19.

Although many plant species were recorded, relatively few occurred on more than 15 percent of the sites. The site occurrence of shrub-tree overstory was made up of the following percentages: alder, 56; crab apple, 42; hawthorn, 19; silky dogwood, 19; blackberry, 19; and willow, 14. Occurring less frequently, gray dogwood, red maple, American elm, blue beech, choke cherry and aspen were common associates. In the herbaceous understory, grasses, goldenrods and sedges predominated, with an occurrence rating of 92, 65 and 42 percent, respectively. Aster, cinquefoil, jewelweed, sensitive fern, violet and yarrow were the next most common associates.

A statewide survey showed that regional differences exist in the composition of various woodcock cover types. For example, alder was predominant in central and northeastern Pennsylvania, but aspen was more prevalent in the northwestern part. These differences can be noted from data in Table 20, and the illustration in Figure 5. On a statewide basis, however, alder stands out as the most important cover type. Crab apple and hawthorn thickets also play an important but secondary role.

The density and distribution of coverts is perhaps as important as vegetative composition. This applies not only to the overstory but also to ground cover. Woodcock prefer to use the edge rather than the interior of large even-aged stands. Whenever stands were broken up into smaller units, woodcock use was more evenly distributed. Greater year around utilization was noted when coverts were scattered over the terrain; e.g., along both stream bottoms and on adjacent slopes. Under such circumstances woodcock take advantage of changing site conditions brought on by seasonal weather changes.

Ground cover is also an important feature of woodcock coverts and may serve as an indicator of site quality. When ground cover density reaches 25 percent and other features are favorable the site becomes ideal. When ground cover is sparse or absent, the site produces few earthworms or little other woodcock food and as a result is seldom used. On the other hand ground cover may be too dense and hinder probing for food, even though the soil beneath has an abundance of earthworms.

TABLE 17

Sex and Age Composition from Fall Collected Woodcock Wings

Year	Number of Wings	Percent of Total Kill Adult Male	 Female	 Immature Male	 Female	Age Ratio Immatures Per Adult	Adult Sex Ratio Males Per 100 Females
1958	304	25	32	22	21	.75	78
1959	543	21	26	27	26	1.28	84
1960	743	19	29	27	25	1.08	64
Combined	1590	21	29	26	24	1.01	73

TABLE 18

Life Equation of a Stable Woodcock Population

		Population	
Item	Gain	Loss	Total
Breeders Based on: 48 males (known 5-year average) 66 females (assuming sex ratio same as fall, i.e. 73 males per 100 females)	114		114
Young Based on: 70 percent nesting success 3.03 chicks per average brood	134		248
Adult mortality (spring to fall) Based on: Estimate of 5 percent		6	242
Juvenal mortality (spring to fall) Based on: 15 percent loss, difference between age ratio soon after hatching (1.18) and in fall (1.01)		20	222
Hunting season kill Based on: Known 5-year average total kill of 65, and estimates 70 percent resident woodcock		45	177
Winter loss Based on: Deduction		63	114

Soil Properties

Early in the woodcock management study it was learned that habitat requirements encompassed more than vegetative composition alone. Part of a preliminary report by the author (1956) is quoted to illustrate this point: "It is commonly known that woodcock have definite habitat requirements, usually fulfilled by young growth less than twenty-five years of age. This growth appears to be restricted to a few specific cover types, but age and type of cover alone do not insure woodcock usage. Other factors are obviously involved.

"One of the more important of these may be food supply. Previous food habits studies of woodcock have shown that the great bulk of the diet consists of earthworms. Further, Mendall and Aldous (1943) state that in parts of Maine where there are few or no earthworms there are no woodcock. Perhaps in areas where the supply of earthworms is limited or when this dietary item becomes unavailable to woodcock, such as during extended periods of drought, the birds are forced to move to better locations or to change their feeding habits.

"It is entirely possible, therefore, that woodcock distribution and numbers are highly dependent upon the supply and availability of earthworms. In turn, the supply of earthworms may be greatly influenced by such factors as vegetative cover, soil texture, soil organic and mineral content, or a number of other variables. Perhaps a few of these variables could be singled out and serve as a key to woodcock distribution."

Exploratory investigations were made to confirm these suspicions. One such study dealt with measurements of the relative abundance of earth-

TABLE 19

Frequency of Occurrence of Plant Species on 62 Woodcock Flushing Sites in the Bald Eagle Study District During Summer and Fall

Plant Species*	Frequency of Occurrence	
Trees and Shrubs	**No.**	**%**
Common Alder	35	56.4
Crab Apple (and Hawthorn)	26	41.9
Silky Dogwood	12	19.2
Blackberry	12	19.2
Willow	10	16.0
Dewberry	9	14.4
Gray Dogwood	7	11.2
American Elm	7	11.2
Red Maple	7	11.2
Common Elder	7	11.2
Choke Cherry	6	9.6
Virgin's Bower	6	9.6
Blue Beech	5	8.0
Aspen	5	8.0
Raspberry	5	8.0
Conifers	4	6.4
Ninebark	4	6.4
Poison Ivy	4	6.4
Black Cherry	3	4.6
White Ash	3	4.6
Rose	3	4.6
Red Oak	2	3.2
Meadow	2	3.2
Witch-hazel	2	3.2
Viburnum	2	3.2
Black Birch	1	1.6
Tulip Poplar	1	1.6
Spicebush	1	1.6
Virginia Creeper	1	1.6
Allegheny Plum	1	1.6
Grape	1	1.6
Herbs	**No.**	**%**
Grass	57	91.9
Bluegrass	38	61.2
Poverty-Grass	21	33.8
Panic-Grass	7	11.2
Other	8	12.9
Goldenrod	40	64.5
Goldenrod (1)	15	24.3
Goldenrod (2)	13	20.9
Goldenrod (3)	18	29.0
Sedge	26	41.9
Cinquefoil	24	38.7
Aster	21	33.9
Moss (Common)	19	30.4
Jewelweed	17	27.4
Yarrow	13	20.8
Violet	12	19.2
Tall Meadow-Rue	10	16.0
Wood Sorrel	10	16.0
Sensitive Fern	8	12.8
Strawberry	7	11.2
Rough Bedstraw	7	11.2
Boneset	6	9.6
Joe-Pye-weed	5	8.0
Wild Carrot	4	6.4
Black Bindweed	4	6.4
Plantain	3	4.8
Common Smartweed	3	4.8
Ragweed	3	4.8
Geranium	3	4.8
Rue-Anemone	3	4.8
Everlasting	3	4.8
Ironweed	2	3.2
Wild Mint	2	3.2
Fringed Polygala	2	3.2
Whorled Loosestrife	2	3.2
Golden Ragwort	2	3.2
Yellow Dock	2	3.2
Skunk Cabbage	2	3.2
Christmas Fern	2	3.2
Bellwort	1	1.6
Motherwort	1	1.6
Arrow-Leaved Tearthumb	1	1.6
Jerusalem Artichoke	1	1.6
Woodrush	1	1.6
Black Snakeroot	1	1.6
May-apple	1	1.6
Horsetail	1	1.6
White Avens	1	1.6
Bloodroot	1	1.6
Milkweed	1	1.6
Bluets	1	1.6
Heal-all	1	1.6
Daisy-Fleabane	1	1.6
Common Speedwell	1	1.6
St. John's wort	1	1.6
Black-eyed Susan	1	1.6
Timothy	1	1.6
Marginal Shield	1	1.6
Club Moss	1	1.6

*See *Appendix C* for scientific names.

worms within four adjacent types of habitat. These were: 1. cultivated field (corn crop); 2. abandoned field (poverty grass, goldenrods); 3. shrub (alder predominating); and 4. forest (mixed young hardwoods and conifers). Techniques are described earlier in this text. The sampling method was uniform throughout. Samples were taken over a relatively short period during July. These data are presented in Table 21. This compilation indicates that the shrub type habitat produced the greatest number of earthworms. Worm production there was twice that of the next best habitat type. The data also show more earthworms in samples having more herbaceous ground cover, regardless of major habitat type. Subsequent observations showed that woodcock were most abundant in an area with the most earthworms.

A graduate student (D. R. Miller) at Pennsylvania State University studied various soil properties in relation to woodcock habitat. The following presentation includes his salient findings. A more detailed account is given in Miller's thesis (1957) entitled "Soil Types and Earthworm Abundance in Woodcock Habitats in Central Pennsylvania."

Species of Earthworms

Miller (1957) found seven earthworm species on the study areas. These included: *Lumbricus terrestris*, *Lumbricus rubellus*, *Octolasium lacteum*, *Allologophora caliginosa*, *Eisenia lonnbergi*, *Eisenia rosea* and *Dendrobaena octaedra*. As many as four species were found at a single study site. No doubt additional species exist elsewhere in the state. Murchie (1954) found 18 species in Michigan while sampling a greater variety of soil types. He also found that many Michigan earthworms have wide ecological tolerances.

Variability in Earthworm Abundance

Variability in earthworm abundance has long been recognized. Not only do differences exist between sites at the same time but also on the same sites between seasons. Many factors are responsible for these phenomena. Murchie (1954) sums it up this way: "It may be seen from the results of this portion of the investigation that certain cyclic phenomena, such as aestivation, in the biology of earthworms are obscured by changes in environmental conditions. Prolongation of cocoon life, the migration into deeper soil layers, and the time spent in aestivation, are all factors which change, not only from one species to the next, but from one population to another of the same species. Indeed, considerable variation may occur within the same population from season to season. Temperature appears to control the sexual development of individuals, however, in upland populations, the moisture regime is primarily responsible for the composition and activities of the earthworm fauna." Miller (1957) found differences in earthworm abundance in the same sites even during summer months, and during a summer when precipitation was greater than usual.

Hydrogen-Ion Concentration Influence on Earthworms

It appears that soil pH, in itself, is not a limiting factor. Olson (1928) found earthworms in natural soils in Ohio ranging from pH 4.5 to 8.7. Murchie (1954) states that soils above

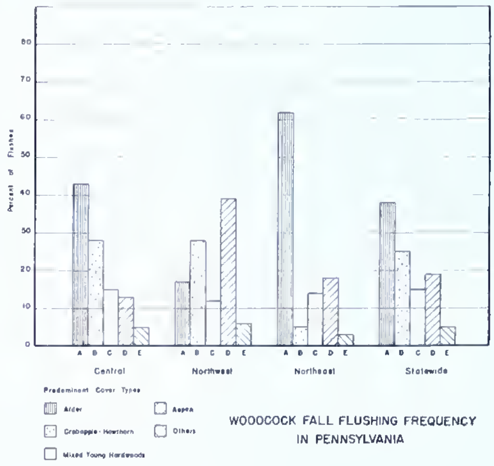


Fig. 5

TABLE 20

Fall Woodcock Flushing Frequency as Related to Cover Type and Geographic Region

Cover Type	Percent of Flushes by Geographic Region							
	Central		Northwest		Northeast		Total Pa.	
Pure alder	16		6		3		12	
Mixed—alder predominating	28		10		59		27	
Total: alder		44		16		62		39
Pure crab apple and hawthorn	10		14		1		10	
Mixed—crab apple and hawthorn predominating	17		13		4		14	
Total: crab apple and hawthorn		27		27		5		24
Mixed young hardwoods		14		11		12		13
Aspen		11		40		19		19
Others(old fields, conifer plantations, etc.)		4		6		2		5

pH 6.0 appear to support larger and more diverse populations of worms, and that this factor probably exerts whatever influence it may have on a regional scale rather than within microhabitats. Miller (1957) found earthworms most abundant in soils with a pH between 4.6 and 6.0 where the total range was 4.1 to 6.4. Hydrogen-ion content, therefore, should be considered as only one of several soil properties governing earthworm occurrence.

Soil Texture Effect on Earthworms

Soil texture reflects its ability to retain moisture, another property to consider in evaluating earthworm habitat. Miller (1957) found earthworms more abundant in sandy loam and loam-textured soils than in clay or silt soils. Murchie's more detailed study (1954) showed that where sand content rose above 80 percent, earthworm abundance decreased. He further stated that high percentages of sand were often compensated for by good moisture and an accumulation of litter. These supplemental factors became more important as the percentage of sand increased above 75 percent.

Soil Moisture Effects on Earthworms

According to Miller (1957), extremes in soil drainage appear detrimental to both earthworm abundance and woodcock occurrence. Previous investigators made somewhat similar observations. Olson (1928) stated that most worms were found in soils of from 12 to 35 percent moisture content. Evans and Guild (1948) found maximum earthworm production in soils of 28 to 42 percent moisture content and Murchie (1954) states: "As the water holding capacity falls below 45 percent, the well-drained upland soils are not suitable for the maintenance of large or diverse earthworm populations. The highly organic soils, those with water holding capacities over 100 percent, likewise show a decline in earthworm numbers."

Influence of Organic Matter on Earthworm Supply

In reference to organic matter Miller (1957) concludes: "Of all the soil properties studied the organic matter content showed the least effect on both earthworm abundance and woodcock occurrence. Earthworms were found abundant and scarce in soils with high and low percentages of organic matter." On the other hand, Olson (1928) found most earthworms where the organic matter was 4 or 5 percent, and further stated that very high and very low amounts of organic material in the soil were deleterious to earthworms. Murchie (1954) suggests that in those situations where soil moisture level is near minimum earthworm tolerance, the amount of organic material may very well become an effective limiting factor. He found, however, that in most Michigan soils organic matter was not as important as soil texture and drainage.

Relationship of Soil Properties to Each Other and to Earthworms

Of the various soil properties discussed previously none were found to specifically limit earthworm populations. Obviously many compensating factors are at work, and several aspects must be considered at a given time. On the other hand, certain soil features appear more important than others. These data suggest that soil drainage is more important than any other factor in determining soil suitability for earthworm production.

Primary Cover Type Analysis

Woodcock have rather definite habitat requirements, and these are met by relatively few vegetation types. It is essential to know the basic underlying ecological factors to formulate management techniques. An ecological study of several more important types was undertaken. Field work generally consisted of collecting data on floral composition, stem growth and stand development, earthworm abundance, soil properties, land use history, and woodcock utilization in each type.

Alder

Sites most consistently inhabited by woodcock had a preponderance of alder in their vegetative make-up. Yet, not all alder coverts support woodcock. Some do and some do not.

TABLE 21

Earthworm Abundance in Several Habitat Types at Three Locations

Habitat Type	Approx. % Herbaceous Cover	Soil pH	Soil Moisture (Percent)	Earthworms Per Sample By Method (1)* No.	Vol. (cc)	By Method (2)* No.	Vol. (cc)
I. Cultivated corn field	0		12	5	5	1	2
	30		11	13	12	31	17
	60		12	17	19	27	15
Average:				12	12	20	11
II. Abandoned field (Poverty grass, goldenrod)	5	4.8	12	0	0	1	1
	40	5.6	10	2	2	12	3
	100	6.3	12	11	6	35	4
Average:				4	3	16	3
III. Shrub (Alder predominating)	5	6.2	16	20	12	63	25
	50	6.2	13	20	19	61	50
	80	6.2	13	33	20	62	34
Average:				24	17	62	36
IV. Forest (Mixed) young hardwood-conifer	5	4.6	8	0	0	8	2
	30	5.1	8	3	2	86	21
	70	5.0	8	11	6	28	17
Average:				5	3	40	13

**Method (1) by digging; method (2) by use of* $KMnO_4$.
Note: Soil surface air temperatures at time of sampling 72° F. to 82° F.

WOODCOCK GENERALLY PREFER nesting sites in the edges of small trees or shrub thickets. Examination of nest sites revealed hawthorn and crab apple occurred most frequently.

Composition of Vegetation

The association of certain plant species with specific cover types is becoming more apparent. Indicator plants in the herbaceous ground layer have been established for several plant communities. The application of this technique to woodcock habitat warrants further intensive study.

The species composition of 35 alder stands is presented in Table 22. The table reveals both species occurrence and percent cover.

Although many plants occur frequently in alder stands, only a few are characteristic. These included silky dogwood, black willow, jewelweed, and sensitive fern, while blackberry, choke cherry, elm, goldenrod, blue grass, violets, and asters were considered common associates.

The percentage of plant cover per species varied from 1 to 60 percent. Generally the younger the alder stand the greater the percentage of herbaceous ground cover. Ground cover percentage also increased when alder stands became over-mature. Depending on age of the stand, total overstory ranged from 10 to 95 percent, while total ground cover ranged from 20 to 95 percent. The ideal situation for woodcock occurred with an overstory of about 70 percent and ground cover—30 percent.

Stem Growth and Stand

Alder coverts are most attractive to woodcock when between 10 and 20 years old. Stems of 386 alder in 35 stands were measured to determine growth rate and vigor. Figures 6 and

TABLE 22

Floristic Composition of 35 Alder Stands in Central Pennsylvania

Plant Species*	Percent Occurrence	Percent Cover (Average)
Trees & Shrubs		
Common Alder	100	60
Silky Dogwood	37	2
Blackberry	37	5
Black Willow	31	5
Wild Black Cherry	29	3
Hawthorn	26	2
Ash	23	2
Elderberry	20	
Maple	17	
Dentate Viburnum	17	
Choke Cherry	14	
Elm	11	
Raspberry	11	
Black-haw Viburnum	11	
Ninebark	9	
Apple	9	
Walnut	9	
Aspen	9	
Gray Dogwood	6	
Spiraea	6	
Flowering Dogwood	3	
Shadbush	3	
Hemlock	3	
Tulip Poplar	3	
Pine	3	
Herbs:		
Goldenrod (1)	91	5
Bluegrass	83	9
Asters	70	2
Goldenrod (2)	69	4
Violet	69	3
Cinquefoil	63	3
Heal-all	60	1
Jewelweed	54	5
Moss, Ground	54	3
Sedges	49	7
Panic-Grass	49	2
Dewberry	49	7
Wood Sorrel	49	1
Virgin's Bower	40	3
Joe-Pye-weed	40	2
Yarrow	40	2
Wild Mint	40	1
Ragweed	34	1
Meadow-Rue	34	1
Plantain	31	1
Poverty-Grass	31	12
Sensitive Fern	31	4
Boneset	29	1
Bedstraw	29	1
Whorled Loosestrife	29	1
Speedwell (Common)	26	2
Daisy-Fleabane	23	1
(Understory Ground Cover)		
Wild Geranium	23	1
Grasses (all other)	23	2
Goldenrods (other)	20	3
Wild Carrot	20	3
Arrow-Leaved Tearthumb	20	3
Smartweeds	20	2
Turtle Head	20	1
Clovers	17	2
Curled Dock	17	1
Mallow	17	2
Black Bindweed	14	2
Early Everlasting	14	1
St. John's Wort	14	3
Mother Wort	14	1
Horsetail	14	3
Virginia Creeper	14	2
Ironweed	11	1
Black-eyed Susan	11	2
Water Pennywort	11	3
Jack-in-the-Pulpit	9	1
White Avens	9	1
Wild Strawberry	9	1
Wild Onion	9	3
Bellwort	6	2
Woodrush	6	1
Turk's Cap Lily	6	1
Woodsia Fern	6	2
Blue Vervian	3	1

**See Appendix C for scientific names.*

7 illustrate average growth and density at various stages of development.

Several deductions can be made from these figures. Stem growth is most vigorous from 1 to 8 years. This period represents the invasion of alder into old fields or similar sites not inhabited by other woody plants. With little or no competition stems grow vigorously. At about 10 years crowding becomes evident. New stem growth then levels off and remains static for another 10 years. After about 20 years, many stems begin to die off from old age and competition. The few remaining stems continue to flourish for another 5 to 10 years. Very few stems reach 30 years of age. Unless rejuvenated alder types in Pennsylvania are usually replaced by trees.

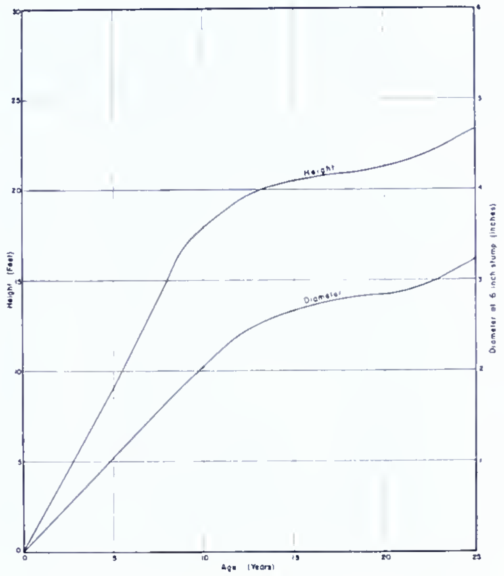
Woodcock Utilization of Alder Habitat in Relation to Earthworm Supply

Having found a relationship between the earthworm-woodcock supply in diverse vegetative types, it was suspected that a comparable relationship might exist between sites having similar plant cover. Seventeen sites dominated by alder were selected for investigation. Prior to sampling each site was classified as poor, fair, or good, based upon knowledge of woodcock utilization. The average number and volume of earthworms per unit sample for each site are presented in Figure 8.

Sites producing many earthworms were those rated high in woodcock utilization, and conversely, sites low in earthworms were seldom visited by woodcock (See Table 23). Soil condition was the best indicator of earthworm production and woodcock utilization. Excessive moisture or excessive drainage, sand or silt, or some other soil property, resulted in a dearth of earthworms. Sufficient data were not acquired to single out specific controlling factors. In this light the need for additional study became evident. The study conducted by Miller in 1954 and reported later represents further exploration of this subject.

Aspen

Aspen habitats ranked high among preferred vegetative types used by woodcock. This was especially true when stands were young and located on sites favoring earthworm production. Although most freqently used as nesting and resting sites, aspen habitats also were used as feeding grounds. Where alder and hawthorn thickets were scarce or missing aspen often filled the need.



AVERAGE HEIGHT AND DIAMETER GROWTH OF ALDER STEMS IN PENNA.

Fig. 6

This study phase was designed to determine whether or why certain aspen sites were preferred over others. Techniques used were similar to those employed in the alder study, as was the late summer study season.

Vegetative Composition

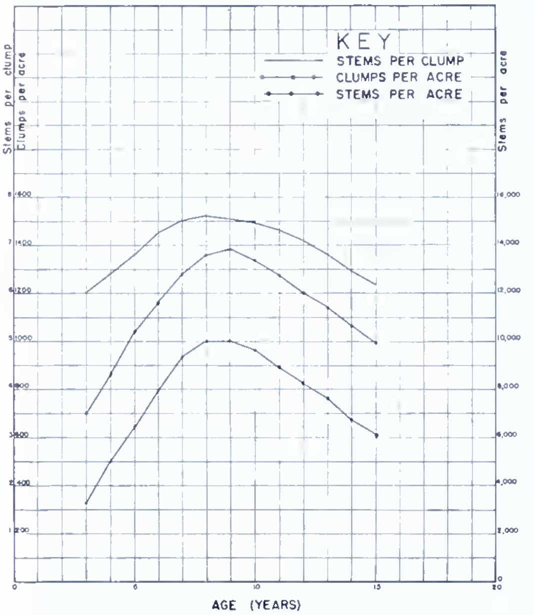
Plant species were listed for 27 quaking aspen sites in central Pennsylvania. The stands could be considered as being nearly pure aspen.

Hawthorns, blueberries, black cherry, red maple and scrub oak were the most frequent tree and shrub associates of aspen; while grasses, sedges, goldenrods, yarrow and cinquefoil were common herbaceous plants. The grasses, in order of frequency of occurrence, were panic, poverty and blue. Detailed floral composition is given in Table 24.

Stem Growth and Stand Development

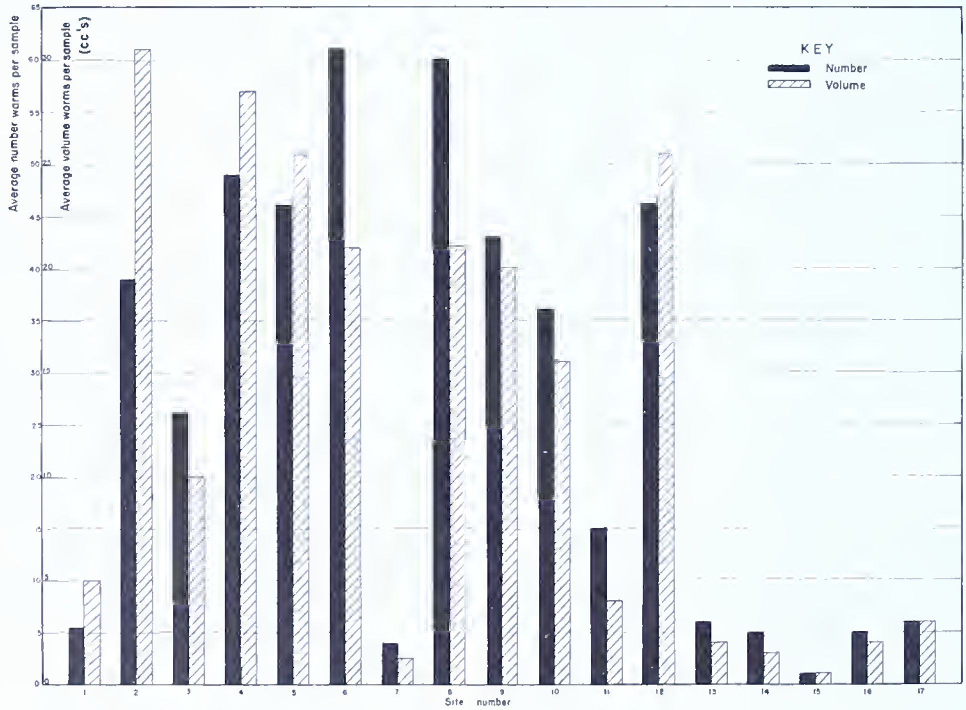
The aspen stands examined grew on a wide variety of sites. The relationship between growth rate and stand development to quality of site may be seen in Figure 9. The graph not only shows aspen growth rates in central Pennsylvania, but also comparable growth rates in west-central Maine described by Wiegle and Frothingham (1911). On the average site in central Pennsylvania, aspen attains a height of approximately 50 feet in 50 years, whereas it reaches approximately 65 feet in 50 years in Maine.

The longer growth cycle, as compared with alder, might make it more appropriate to manage aspen, especially on poorer sites, for wildlife instead of for wood products. This would be accomplished by employing a shorter cutting cycle, which also would retard the invasion of other plant species. Such an environment would be favorable to both woodcock and other wildlife.



AVERAGE DENSITY MEASUREMENTS OF ALDER STANDS IN CENTRAL PENNSYLVANIA

Fig. 7



NUMBER AND VOLUME OF EARTHWORMS IN ALDER HABITATS

Fig. 8

TABLE 23

Earthworm Supply and Woodcock Utilization in Alder Habitats

	Utilization Rating							
	Poor			Fair			Good	
Site No.	Earthworms* No.	Vol. (cc.)	Site No.	Earthworms No.	Vol. (cc.)	Site No.	Earthworms No.	Vol. (cc.)
7	14	5	1	113	89	4	149	85
11	44	14	2	118	93	6	929	318
13	20	7	3	77	30	8	536	190
14	47	19	5	287	160			
15	0	0	9	392	181			
16	41	21	10	320	138			
17	20	11	12	139	76			
Total	186	77		1446	767		1614	593
Avg.	5.6	2.3		34.4	18.3		59.7	21.9

**Average per sample.*

Woodcock Utilization of Aspen Stands in Relation to Earthworm Study

The relationship between earthworm availability at a given site and its utilization by woodcock was most evident in the aspen studies. At the season of the study (late summer) sites having no earthworms near the surface were not used by woodcock. On the other hand, sites with earthworms available were utilized (see Table 25). Once again soil properties appeared to be the controlling factor, the most critical of which seemed to be moisture. Sites which held no earthworms or woodcock in midsummer were often used in the spring when soil moisture was high and earthworms were near the surface.

Hawthorn

Hawthorns are among the most valuable wildlife plants. They not only provide food for grouse, deer, turkey, rabbits and squirrels but also are associated with the better woodcock coverts. Limited work conducted under this study included examination of several hawthorn communities to determine floral composition, stem growth, stand development, and woodcock utilization.

Composition of Vegetation

The floral structure of hawthorn stands studied was strongly influenced by domestic stock grazing. The ability of hawthorn to withstand heavy browsing pressure is high compared to many other species. As a result, pure haw-

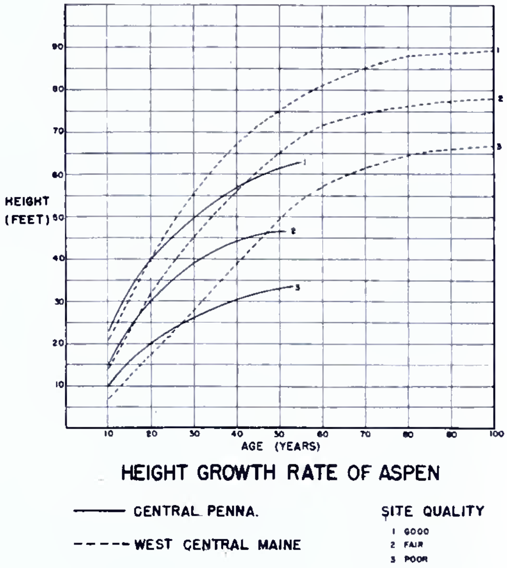


Fig. 9

TABLE 24

Floristic Composition of 27 Quaking Aspen Stands in Central Pennsylvania

Plant Species*	Percent Occurrence	Percent Cover (Av.)
Trees and Shrubs		
Aspen	100	48
Hawthorn	67	2
Blueberry	48	5
Black Cherry	48	2
Dewberry	48	4
Red Maple	41	1
Scrub Oak	26	16
Willow	22	1
Dentate Viburnum	22	2
Blackberry	18	3
Silky Dogwood	18	1
Gray Dogwood	18	4
Oak	18	1
Sumac	15	1
Pitch-Pine	11	2
Crab Apple	11	1
Elderberry	7	1
Raspberry	7	2
Deerberry	7	2
Spiraea	7	1
Hazelnut	7	11
Hickory	7	1
Witch-hazel	4	2
Apple	4	1
Juneberry	4	1
Red Pine	4	5
Banks Pine	4	2
Beech	4	1
White Spruce	4	1
Choke Berry	4	1
Blue Beech	4	1
Choke Cherry	4	1
Herbs		
Grasses (all)	89	14
Goldenrod (all)	89	16
Cinquefoil	85	3
Yarrow	70	1
Sedges	63	3
Strawberry	63	2
Hair-Cap Moss	37	4
Panic-Grass	33	5
Common Moss	33	2
Teaberry	30	1
Wood Sorrel	33	1
Aster	26	1
Violet	22	1
Whorled Loosestrife	22	1
Wild Rose	22	1
Bracken Fern	18	2
Early Everlasting	18	1
Wild Geranium	15	1
Poverty-Grass	11	20
Sweetfern	11	8
Bluegrass	11	4
Dogbane	11	1
Sensitive Fern	7	2
Joe-Pye-weed	7	1
Wild Mint	7	2
Poison Ivy	7	1
Milkweed	7	1
Ragweed	7	10
Sphagnum Moss	7	1
Hawkweed	7	1
Woodrush	7	1
Ragwort	7	1
Bellwort	7	2
Water-Hemlock	7	1
May-apple	7	4
Virgin's Bower	7	1
Sheep Sorrel	7	1
Woodsia Fern	4	1
Thistle	4	1
St. John's-wort	4	1
Bedstraw	4	2
Artichoke	4	1
Club Moss	4	5
Pearly Everlasting	4	1
Speedwell	4	1
Daisy	4	1
Daisy-Fleabane	4	1
Rue-Anemone	4	1
Barren Strawberry	4	30
Jewelweed	4	1
Boneset	4	1

**See Appendix C for scientific names.*

thorn stands often develop in pastured areas.

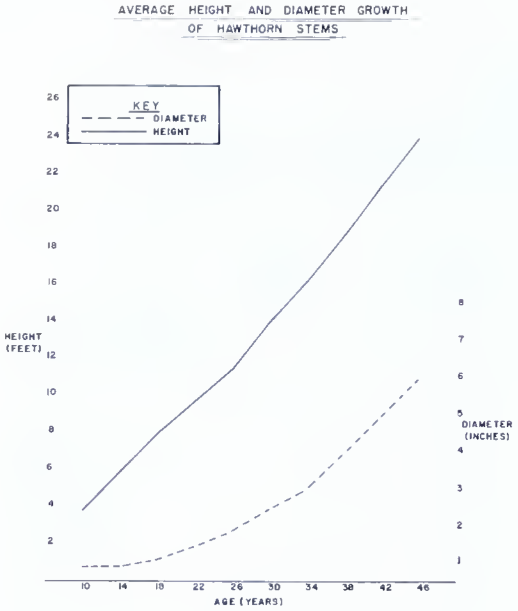
A tally of woody stems, by species and diameter class, for hawthorn stands of different densities is presented in Table 26. The percentage of hawthorn stems in the stand composition varied from 69 to 92 percent. While the range in frequency of occurrence of individual hawthorn species was even greater, a few species were most abundant. These were *Cra-*

TABLE 25

Woodcock Utilization of Aspen Stands Related to Stand Age, Earthworm Supply and Soil Moisture

Degree of Stand Utilization by Woodcock															
1. None				2. Light				3. Moderate				4. Heavy			
Stand Age	Earthworms** No.	Earthworms** Vol. (cc.)	Soil Moisture	Stand Age	Earthworms No.	Earthworms Vol. (cc.)	Soil Moisture	Stand Age	Earthworms No.	Earthworms Vol. (cc.)	Soil Moisture	Stand Age	Earthworms No.	Earthworms Vol. (cc.)	Soil Moisture
13	0	0	1	14	1	1	2	15	2	1	2	8	25	7	3
11	0	0	1	16	0	0	1	11	7	6	2	10	26	18	2
11	0	0	1	11	4	1	1	9	8	5	2	11	11	8	2
28	0	0	1	22	10	6	2	9	3	2	2				
12	0	0	1	8	2	1	1	32	2	1	2				
35	0	0	1	7	4	2	2	14	8	4	2				
8	0	0	1	15	2	1	1								
3	0	0	1	42	6	4	3								
8	0	0	1	8	2	2	3								
35	0	0	1	14	7	4	2								
5	0	0	1	21	1	1	2								
32	0	0	1	20	1	1	1								
7	0	0	1	16	0	0	2								
7	0	0	1	14	0	0	2								
3	0	0	1												
30	1	1	1												
12	0	0	1												
Average															
15	—1	—1		16	2.8	1.7		15	5.1	3.1		10	20.6	11.0	

*Key to Soil Moisture: 1.—Dry; 2.—Fresh; 3.—Moist. **Per Sample.*



AVERAGE HEIGHT AND DIAMETER GROWTH OF HAWTHORN STEMS

Fig 10

teagus dilatata, C. pruinosa, and *C. punctata.* Poverty grass and sedges comprised the primary herbaceous ground cover on higher, drier hawthorn coverts while blue grass and panic grass occurred with poverty grass on more fertile sites near stream bottoms. Other common herbaceous associates were goldenrod, cinquefoil, violet, aster, and strawberry.

Stem Growth and Stand Development

A history of grazing in hawthorn communities also was reflected in stem growth. Hawthorn growth often is retarded by severe browsing, but the plant seldom dies. When browsing pressure decreases, or the plant grows out of the animals' reach, height and diameter growth accelerate. Low growing species (*C. Dodgei,* and *C. Margaretta*) were not used in growth curves found in Figure 10.

Study of hawthorn stands of various densities revealed findings pertinent to both stand development and species composition. Since grazing pressure in the study area was absent during the last 15 years, invasion by other species appeared to be controlled by hawthorn stand density and proximity of the seed source. Cherry, ash, red maple, and white pine were common invaders in more open stands, while elm, sugar maple, and crab apple infiltrated the more dense stands.

Woodcock Utilization of Hawthorn Stands

Hawthorn and crab apple thickets were among the preferred types of habitat frequented by woodcock. This was especially true when coverts were adjacent to streams or on lower slopes where spring seeps were common. Although more often used as nesting and resting sites, hawthorn stands often provided good feeding sites. Insufficient data were acquired to draw a correlation between earthworm abundance in hawthorn stands and site utilization by woodcock.

Gray Dogwood

Gray dogwood is one of Pennsylvania's most common native shrubs and also one of the most valuable to wildlife. Its growth on a wide variety of sites is seldom equalled by other shrub species. This plus production of a good annual crop of highly preferred game food at an early age makes it a choice plant for numerous forms of wildlife. Woodcock frequently use this cover type.

Composition of Vegetation

Gray dogwood is commonly recognized by its growth characteristics. A good root sprouter, it generally is found in thickets along fencerows, woods edges, and in abandoned fields. Although mostly occurring in pure thickets it will persist in mixtures. Hawthorns, elms, and ashes are commonly a part of the overstory while grasses, sedges, goldenrods and cinquefoil are common ground cover companions. A complete listing of associate plant species is given in Table 27.

Density of the understory or ground cover in gray dogwood thickets seldom exceeds 50 percent. This is one reason

TABLE 26

Overstory Composition of Three Hawthorn Stands

	Site #1 (.25 A.) D. B. H. (inches)								Site #2 (.25 A.) D. B. H. (inches)							
Species	0.5-2	3-4	5-6	Total		Percent		:	0.5-2	3-4	5-6	7-8	Total		Percent	
Hawthorns:								:								
Crataegus dilatata	39	17	5	61)	266	18)	78	:	188	93	18	7	306)	437	64)	92
Crataegus pruinosa	25	6		31)		9)		:	37	6			43)		9)	
Crataegus punctata	6	7	2	15)		4)		:	13	32	12		57)		12)	
Crataegus Holmesiana	32	11		43)		13)		:		7	6		13)		3)	
Crataegus macrosperma	25	13		38)		11)		:					)		)	
Crataegus Dodgei	9	1		10)		3)		:					)		)	
Crataegus Margaretta	6			6)		2)		:					)		)	
Crataegus (Unidentified)	56	6		62)		18)		:	12	6			18)		4)	
Other Species:								:								
Crab Apple	7		8	15)	76	4)	22	:	13	13		6	32)	39	7)	8
Wild Black Cherry	33			33)		10)		:					)		)	
Black Walnut	3			3)		1)		:					)		)	
Red Maple	7			7)		2)		:					)		)	
Choke Cherry	3			3)		1)		:					)		)	
Ash	10			10)		3)		:					)		)	
Elm				)		)		:					)		)	
Sumac	2			2)		1)		:					)		)	
Black Locust				)		)		:		7			7)		1)	
Sugar Maple				)		)		:					)		)	
Apple	1	2		3)		)		:					)		)	
Total:	264	63	15	342				:	263	164	36	7	476			
Percent:	77	19	4			100		:	56	35	8	1			100	

TABLE 26 (continued)

Overstory Composition of Three Hawthorn Stands

	Site #3 (.25 A.) D. B. H. (inches)						Site 1, 2, 3 Combined (.75 A.) D. B. H. (inches)							
Species:	0.5-2	3-4	Total		Percent		0.5-2	3-4	5-6	7-8	Total		Percent	
Hawthorns:														
Crataegus dilatata	263	76	339)		29)		490	186	23	7	706)		35)	
Crataegus pruinosa	212	25	237)		19)		274	37			311)		16)	
Crataegus punctata	50		50)		4)		69	30			122)		6)	
Crataegus Holmesiana			)	826	)	69	32	18	6		56)	1529	3)	76
Crataegus macrosperma	25		25)		2)		90	13			63)		3)	
Crataegus Dodgei			)		)		9	1			10)		1)	
Crataegus Margaretta			)		)		6				6)		—1)	
Crataegus (Unidentified)	100	75	175)		14)		168	87			255)		12)	
Other Species:														
Crab Apple	201	62	263)		23)		221	75	8		310)		16)	
Wild Black Cherry			)		)		33				33)		2)	
Black Walnut			)		)		3				3)		—1)	
Red Maple			)		)		7				7)		—1)	
Choke Cherry			)		)		3				3)		—1)	
Ash			)	361	)	31	10				10)	476	1)	24
Elm	73	12	85)		7)		73	12			85)		4)	
Sumac			)		)		2				2)		—1)	
Black Locust			)		)			7			7)		—1)	
Sugar Maple	13		13)		1)			13			13)		1)	
Apple			)		)		1	2			3)		—1)	
Total:	937	250	1187				1451	479	37	7				
Percent:	80	20			100		73	24	2	1	2005		100	

TABLE 27

Floristic Composition of 18 Gray Dogwood Thickets in Central Pennsylvania

Species Composition*	Percent Occurrence	Percent Cover (Avg.)
Herbs		
Grass	89	15
Goldenrods	72	3
Cinquefoil	67	2
Moss (Common)	62	5
Sedge	55	7
Bedstraw	55	1
Yarrow	50	1
Strawberry	50	1
Aster	33	3
Heal-all	33	1
Common Speedwell	28	1
Wood Sorrel	28	1
Wild Geranium	28	1
Dewberry	22	1
Hawkweed	17	1
Moss, Hair-Cap	11	1
Rue-Anemone	11	1
Wild Mint	11	1
Barren Strawberry	11	1
Early Everlasting	11	1
Teaberry	11	1
Ragwort	11	3
Bellwort	11	1
Jewelweed	6	5
Dogbane	6	5
Wild Carrot	6	1
Grape Fern	6	1
Black Bindweed	6	2
Ragweed	6	1
Canada Thistle	6	1
Thimbleweed	6	1
Plantain	6	1
Jerusalem Artichoke	6	1
Trees and Shrubs		
Gray Dogwood	100	79
Hawthorn	33	1
Scrub Oak	33	18
American Elm	22	1
Poison Ivy	22	20
Ash	17	1
Wild Black Cherry	12	1
Blueberry	12	8
American Hazelnut	12	1
Virginia Creeper	12	2
Wild Rose	12	2
Crab Apple	12	1
Wild Plum	6	1
White Pine	6	1
Table Mountain Pine	6	1
Sassafras	6	1
Smooth Sumac	6	1

**See Appendix C for scientific names*

woodcock prefer this type. With sparse ground cover, earthworms and other food are more accessible than when the ground is heavily matted with herbaceous vegetation.

Stem Growth and Stand Development

Gray dogwood is a relatively slow-growing species. A 10-year-old stand of gray dogwood is seldom over 6 feet high, and at 20 years it reaches a maximum height of 9 feet (see Figure 11). Peak years for fruit production appear to come between the ages of 5 and 15 years. Later the stems begin to deteriorate, and most are dead at 20 years.

Gray dogwood thickets appear to originate at a central point from seedlings and spread by root suckers from the original site. As the stand develops natural thinning takes place. Figure 12 shows that as a gray dogwood stand matures from 5 to 15 years, the average number of stems per 100 square feet decreases from 120 to 20. Normally the stand is replaced by longer-lived and more tolerant trees, but some stands seem to regenerate themselves. In several instances when older stems were dying, vigorous new shoots were replacing them. This matter needs further study.

Woodcock Utilization of Gray Dogwood Thickets in Relation to Earthworm Supply

Woodcock exhibited a definite preference for gray dogwood thickets,

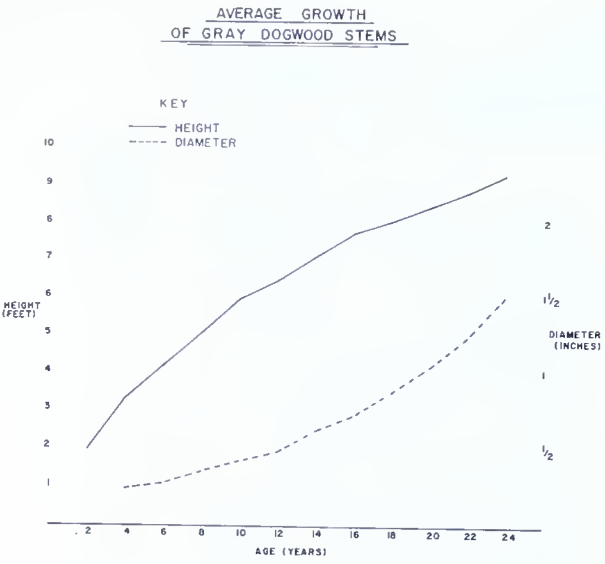


Fig. 11

even where other shrub types were available. Just as with alder and aspen, however, all gray dogwood thickets were not used. Preference was exhibited only when coverts were located on relatively fresh or moist soils where earthworms were abundant. A study of 18 well-known gray dogwood thickets, presented in Table 28, helped substantiate this observation.

Relative Importance of Habitat Factors

After studying habitat used by woodcock, some conclusions should become evident on the importance of its many factors. There seems to be no single habitat component which guarantees woodcock usage. On the other hand, various factors probably can be ranked in order of importance. Cover type could be listed first, soil drainage second, and food supply third. Where food and good drainage occur without cover, woodcock are seldom found. Good cover with poor drainage, and/or food supply also would receive little use. It is pertinent, therefore, that all ecological factors be considered.

It was not concluded that woodcock

TABLE 28

Woodcock Utilization of Gray Dogwood Thickets in Relation to Stand Age, Earthworm Supply and Soil Moisture

	Degree of Utilization by Woodcock								
	1. None			2. Light			3. Moderate		
	Stand Age (Yrs.)	No. of* Earth-worms	Soil Moisture Rating	Stand Age (Yrs.)	No. of* Earth-worms	Soil Moisture Rating	Stand Age (Yrs.)	No. of* Earth-worms	Soil Moisture Rating
	5	6	1	12	11	3	12	49	3
	5	1	1	8	32	2	10	74	2
	6	0	1	14	30	2	7	69	3
	4	0	1	10	15	2	11	43	2
	8	4	1	9	17	2			
	12	0	1						
	10	0	1						
	12	1	1						
	15	1	1						
Avg.	9	1.3	1	11	21.0	2.2	10	58.7	2.5

*Key to soil moisture ratings: 1. 1—Dry; 2. 2—Fresh; 3. 3—Moist. *—Per sample.*

are totally dependent on earthworms for food. It became apparent early in the study that for some reason woodcock do change their location and type of food. Specific data on these changes should be collected by future investigators.

DECIMATING FACTORS

Hunting

Hunting is an important factor limiting local breeding woodcock populations. The extent to which they are limited by hunting is influenced by number of hunters, timing of the hunting season, and size and location of woodcock coverts.

A number of woodcock hunters were requested to record additional data on a prepared form. An intensive survey was made in specific study areas and data also were obtained from hunters throughout the state. Results of this survey are presented in Table 29. It required about 1.5 hours to flush a woodcock, and three hours to effect a kill. Once a hunter found a woodcock there was about a 50:50 chance he would bag it. Woodcock hunters taking part in this survey averaged 30 hours annually in pursuit of their sport.

No accurate tally of woodcock hunters in the state was available. It was interesting, however, to speculate with available data and interpret data collected in other states. Michigan found that 5 percent (35,700) of its small game hunters hunted woodcock in 1955. New York's first woodcock hunter survey (1959-1960) revealed 43,266 gunners. Pennsylvania recently reported that 95 percent of its license holders hunted small game. If the assumption is valid that 5 percent of the small game hunters hunted woodcock in 1955, then 44,000 gunners must have been afield during the season. This figure represents both those individuals who specifically hunted woodcock and also those who killed woodcock along with other hunting.

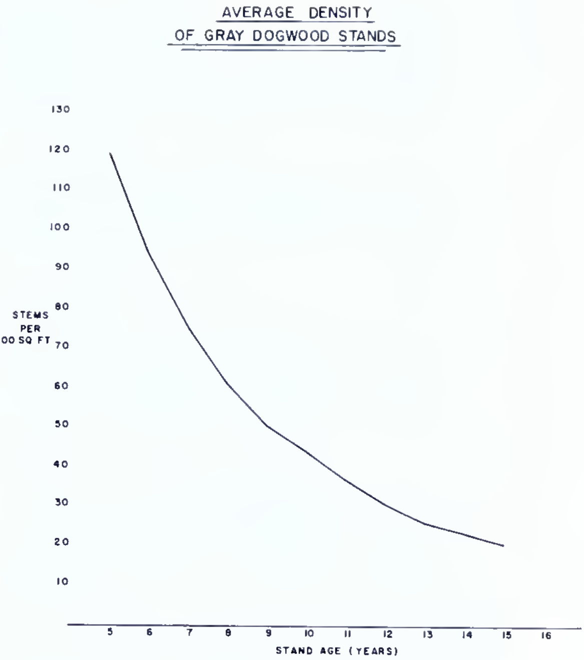


Fig. 12

Data on weekly distribution of woodcock hunting effort and corresponding kill exhibited a pattern similar to that found for other small game. The greatest effort (40 percent) and the greatest kill (37 percent) occurred during the first week of the season (see Table 30). Opening dates for 4 consecutive seasons during which the survey was conducted varied less than 8 days.

Figure 13 illustrates relative changes between hunting effort and kill success as the season progressed. Apparently changes occurred in the type of hunter, and the relative quantity of woodcock available. After the first few days only the more experienced hunters were afield and realized a greater return for their effort. At that time there were usually more woodcock available in proportion to the numbers of hunters afield. It also coincided with the congregation of woodcock prior to migration, and the migration of northern woodcock across the state. The experienced hunter naturally took advantage of these circumstances.

It was concluded that woodcock were exceptionally vulnerable to gun-

TABLE 29
Woodcock Hunting Success Data

	1952	1953	1954	1955	1956	Average
Number of persons receiving questionnaires	26	32	38	37	46	36
Number of persons returning questionnaires	18	29	34	32	39	30
Percent persons returning questionnaires	69%	91%	89%	87%	85%	84%
Total man-hours hunted	434	680	1208	1206	1088	887
Man-hours hunted to flush one woodcock	1.3	1.6	1.3	1.5	1.5	1.4
Man-hours hunted to kill one woodcock	2.5	3.4	3.0	3.4	3.1	3.1
Total number woodcock flushed	343	443	923	699	726	626
Total number woodcock killed	173	199	402	300	353	285
Average kill success	50%	45%	43%	43%	48%	46%
Number of woodcock flushed in study area	165	224	232	202	142	193
Number of woodcock killed in study area	68	86	101	72	58	77
Average kill success in study area	41%	38%	44%	36%	41%	40%

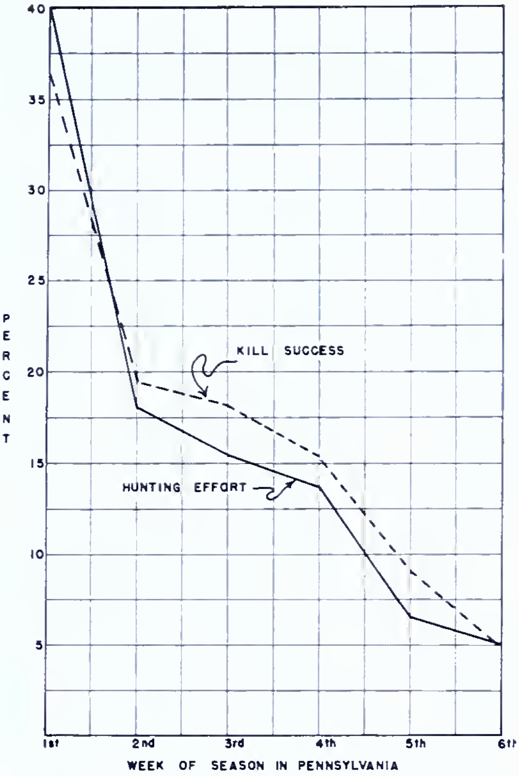
ning. Once flushed, woodcock were rather easily followed. If they were not killed on the first rise, they often were reflushed and shot at a second or third time. The high rate of kill success, however, did not mean that the total population was reduced by similar proportions. Indeed some coverts were seldom, if ever, hunted. On the other hand, many well known coverts were seriously over-harvested. Although over-harvesting was particularly true where coverts were small and more or less isolated, it is not inconceivable that large areas could be similarly affected.

One such example was found in proximately one-half mile by 25 miles in size, contained about 3,000 acres of suitable woodcock habitat. Breeding ground surveys and bag checks were conducted there from 1953 through 1961. The overall trend in both annual census and kill was slightly downward from 1953 through 1961. However, short-term trends in both census and kill were slightly downward from 1953 to 1957 and slightly upward from 1957 to 1961. The average annual breeding population index for this period was approximately one-half that of 1947, according to an earlier survey by Richter (1948). Increased gunning pressure appears to be more responsible for the decline than habitat deficiencies.

An experiment was conducted from 1956-1961 on the effects of controlling hunting pressure on woodcock. Approximately 2,000 acres of State Game Lands 187 in Luzerne County was set aside for this study. The area had a history of persistent and growing hunting pressure and a declining woodcock population. In 1956, hunters were requested to refrain from shooting woodcock in the area. Personal contact and posters (see Appendix E) were used to achieve this end.

Response to this request was indeed heartening and no violations were detected. During the four years the area was closed to woodcock hunting, the spring breeding population increased from 6 to 24 and the pre-hunting season population increased from approximately 18 to 60 woodcock. In 1961, the area again was open to hunting. Forty-five woodcock were bagged during the shooting season. An estimated half of these birds had inhabited the immediate area the preceding spring and summer. Subsequent investigation should reveal the effect of this harvest on the succeeding breeding and fall populations.

Banding records show that locally reared woodcock are bagged in Pennsylvania throughout the season. During the study 153 woodcock were captured and banded in the primary study unit. Fifteen of these turned up in the hunters' bag, fourteen of which were local returns. Of the 14 local returns, 8 were shot within a half mile of the original banding point, 3 within 3 miles, and 3 within 8 miles. Twelve of 14 marked woodcock were shot within 7 months after banding, 1 within 1.5 years and 1 within 2.5 years following banding. Many of these kills occurred late in the hunting season, i.e., the last week in October and the first week in November.



WEEKLY TREND IN WOODCOCK HUNTING EFFORD AND KILL SUCCESS, 1953-1956

Fig. 13

Predation

Predation is not considered a serious limiting factor in woodcock populations. Instances of authenticated predation on adult woodcock were indeed rare. The loss of two adult hens to Cooper's hawks (*Accipiter cooperii*) was noted during the study. The only other known predation occurred at nesting time. Predators accounted for 43 percent of the nest failures. Details are given under the section entitled "Nesting."

Weather

No evidence of woodcock mortality due to adverse weather was recorded. However, it is strongly felt that under special circumstances weather can be a serious decimating factor. Mendall and Aldous (1943) gave a detailed account of some serious losses due to weather in the previous 60 years. These authors wrote, "In conclusion, it may be said that while ordinary periods of adverse weather have little effect on woodcock, certain types of unusual weather conditions—especially prolonged periods of unseasonable snow or cold—will cause considerable losses to the birds, which become very serious when occurring over a widespread area of the range or when occurring in areas of heavy nesting or wintering populations."

TABLE 30

Weekly Distribution of Woodcock Hunting Time and Corresponding Kill Success from a State-wide Four-year Sampling Period (1953-1956)

Man-Hours of Hunting

Year	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	Total
1956	443	165	190	119	96	74	1087
1955	350	155	185	178	79	78	1025
1954	489	224	182	186	61	65	1208
1953	300	156	92	69	51	11	679
Total	1583	701	649	552	287	228	4000
Avg.	395	175	162	138	71	57	1000
Percent	40	18	16	14	7	5	100

Number of Woodcock Killed

1956	160	56	62	39	22	14	353
1955	90	64	63	48	14	21	300
1954	127	58	74	84	35	24	402
1953	82	53	25	28	5	6	198
Total	459	231	224	199	76	65	1253
Avg.	119	58	56	50	19	16	313
Percent	37	19	18	15	6	5	100

Aspects of Population Dynamics

GENERAL

IT IS important in managing game species to be well informed about populations, their trends and patterns of distribution. Certain aspects of population dynamics revealed by this study are discussed below.

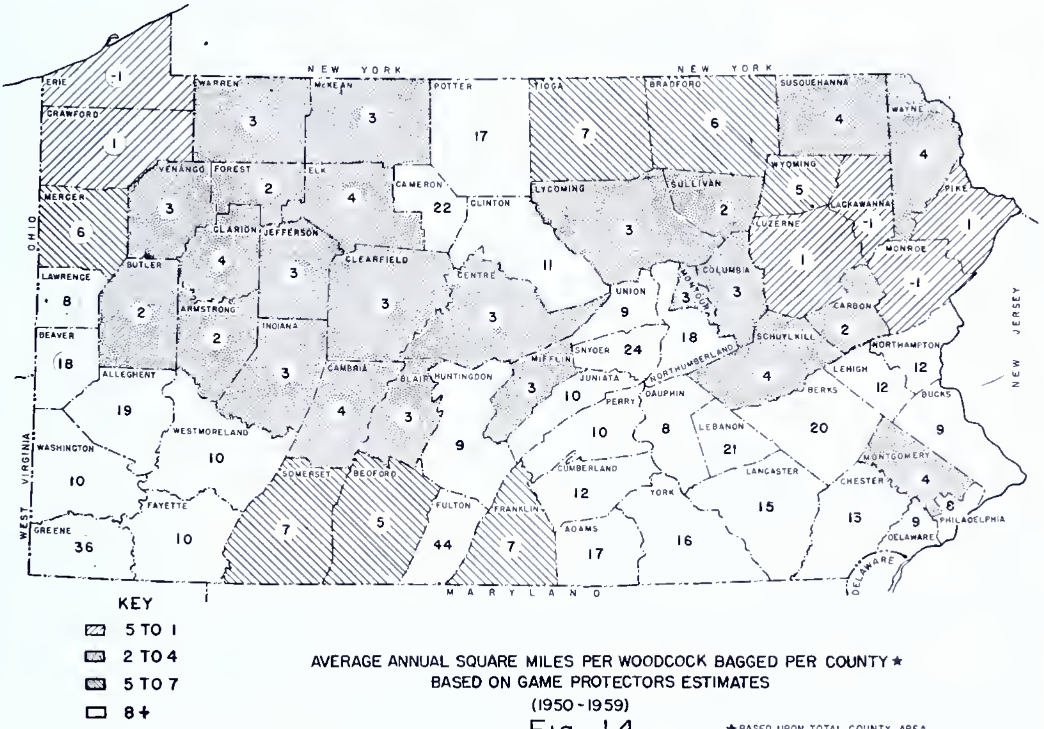
Abundance and Distribution

Woodcock were found at various times in every county of Pennsylvania. Numbers found in each county, however, varied considerably. Even within a county, or smaller unit, distribution was not uniform. So-called "pockets" of woodcock existed in many isolated, often widely separated areas. The distribution and abundance of woodcock throughout the state are shown on the accompanying map (Figure 14).

Distribution and abundance depended on several factors, the most important of which was habitat. Areas containing substantial suitable habitat supported a pair of breeding woodcock per 100 acres in the spring, and about 5 woodcock per 100 acres in the fall. These figures do not refer to a specific covert, where concentrations of up to a bird per acre were found, but rather to a large unit (several square miles) of range.

Woodcock numbers in a particular area or covert varied with season and changing weather. Some areas holding breeding woodcock in the spring did not support birds during droughty parts of the summer and fall. Other areas sustained woodcock the year around, except during winter.

The total acreage of woodcock habitat and the size of the woodcock pop-



AVERAGE ANNUAL SQUARE MILES PER WOODCOCK BAGGED PER COUNTY★
BASED ON GAME PROTECTORS ESTIMATES
(1950-1959)
Fig. 14
★BASED UPON TOTAL COUNTY AREA.

TABLE 31

Woodcock Spring Census Data*

Route	Average Birds Per Route								
	1953	1954	1955	1956	1957	1958	1959	1960	1961
1	3	3	6	1	14	12	13	14	
2	8	11	14	5	6	5	8	9	6
3	8	9	9	8	8	11	18	11	20
4	7	14	13	9	15	9	7		11
5	8	8	11	8	9	8	8	14	8
6	5	5	3	2	4	1	4		2
7	5	6	3	2	1	6		3	
8	6	5	4	4	8	5	4	8	7
9	2	4	3	3	3	3	2	4	2
10	6	3	3	8	7	4			
11	4	2	2	4	1	0			
12	2	3	1						
13		4	3	3	3	0	2	2	3
14		6		3	8	2	6	1	1
15		9	7	4	3	8	10	9	14
16		9	1		15	10	11		
17		6	6	2	4	4	2		
18		4	4	2	3	5			
19		4	2	3	3	9	11	9	11
20		13	12	7	4	5	10	12	12
21		11	8	9	0	6	8	6	5
22		4	3	4	4	4	4	4	3
23		4	4	4	13	5			
24									
25		1	1						
26		12	9	6		5	10		
27			3	0	2	1			
28			5	9	7				
29			3	1	2	2	4	4	5
30			4	6	7	8	6		
31			8	7	9				
32			2	2	4	3	4	7	6
33				7		5			
34				11					
35				10	3				
36					5	4			
37				2	3				
38					9	3	6	4	4
39					5	7	7	3	13
40					3	4			
41					2	2			
42						3			
43						3	3	4	
44						3	3	8	7
45						9			

**Based on singing birds heard.*

ulation in the state are hard to ascertain. It is difficult to calculate the total population because of several unknown factors. No one knows what resident woodcock contribute to the total hunting season harvest nor is it known what percentage of the overall fall population is taken by hunters. However, some new information may permit a reasonable estimate.

One method was to project data presented in the life equation table. For the area from which data were collected an estimated 70 percent of the season bag consisted of native birds, and this bag comprised 20 percent of the pre-season population. Applying these percentages to an estimated statewide kill of 12,000 birds, the calculated pre-hunting season resident population was 42,000 woodcock.

Several procedures were used to estimate the total acreage of woodcock habitat. Once again, certain assumptions were necessary. Assuming that kill reflects the amount of habitat in a given area, counties having a high kill would be expected to contain more habitat than those having a low kill. Using the arbitrary scale listed below, the total habitat area was 780,000 acres.

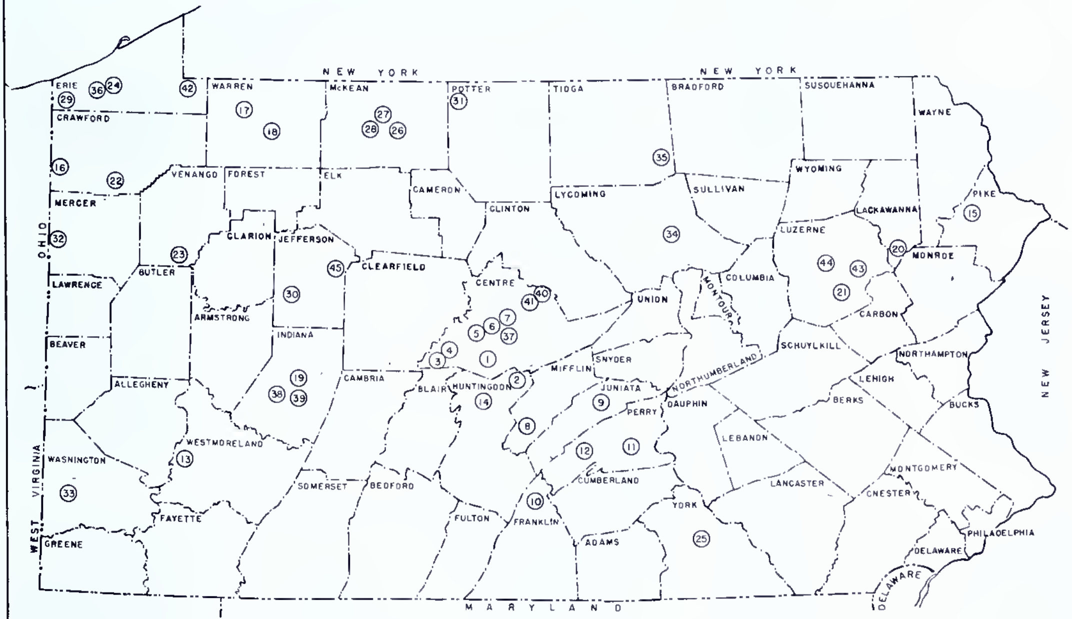
Square miles of land area per county per woodcock killed	*Percent of land area classified as woodcock habitat*
0.5-1	5
2-3	4
4-6	3
7-9	2
10+	1

These values were based on a study of aerial photos of the best woodcock county in the state. Results showed that up to 5 percent of the total land area could be classified as woodcock habitat. This county was then assigned a value of 4 percent in the scale. The process was then repeated for all counties.

Another approach in calculating the total acreage of Pennsylvania woodcock involved use of the estimated fall population of 42,000 birds. Assuming an occupancy rate of 1 woodcock per 20 acres of habitat, the total habitat involves 840,000 acres. This total represents approximately 30 percent of the state's land area.

Census

Population trends may be measured by periodic census. Woodcock are censused each spring by counting the number of birds heard "singing" on mating field along prescribed routes.



WOODCOCK SPRING CENSUS ROUTE LOCATIONS IN PENNSYLVANIA
Fig. 15

The technique is described under the section entitled "Methods."

Forty-five woodcock census routes were established in Pennsylvania. Figure 15 and Table 31 show the approximate location and average number of woodcock heard singing per route for each census year. Detailed census data are available in the project leader's files and those of the Pennsylvania Cooperative Wildlife Research Unit, Pennsylvania State University.

In order to show the true relationship of annual woodcock breeding population indices, the average annual number of woodcock heard singing along the routes was adjusted to a base year. Most available data could be used in this manner and compensations made for variance in number of routes censused each year.

For example, an average of 5.33 birds was heard singing per route in 1953 (base year). In 1954, the average increased by 14 percent. A new average per comparable year was developed by increasing the base year average by 14 percent (5.33 + .75 = 6.08). Subsequent computations followed similar routine.

The same method was used to calculate trends in the Bald Eagle Valley study area. There, 5 routes, each approximately 5 miles long, were censused annually. Data for these and other routes are listed in Table 32 and Figure 16. The latter figure shows a breeding population index for the Bald Eagle Valley study area following that of the statewide trend. There was an obvious trend in the index from 1953 to 1956, and an upswing from 1956 to 1961.

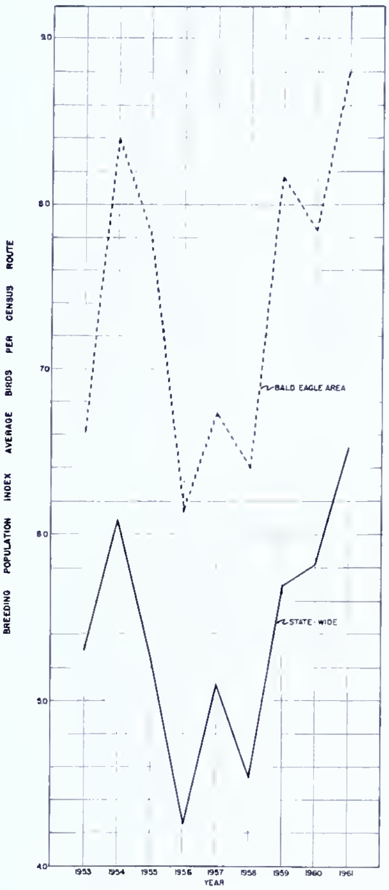
Harvest

Harvest records may be used to detect trends in game populations. The woodcock kill in each county has been estimated by District Game Protectors since 1931. From 1937 to 1944 hunters also were required to report numbers

TABLE 32

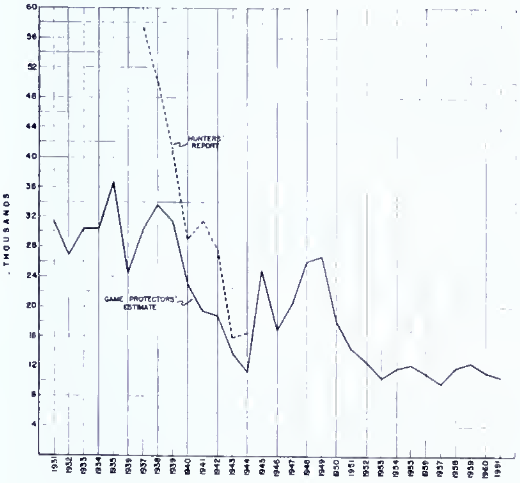
Woodcock Breeding Population Index Data

Comparable Years	Number of Comparable Routes	Average Birds Per Route	Percent Change	Adjusted Average Birds Per Route
		State-wide		
1953-54	12	5.33- 5.08	+14	1954—6.08
1954-55	24	6.41- 5.50	−14	1955—5.23
1955-56	27	5.70- 4.59	−19	1956—4.24
1956-57	29	4.55- 5.45	+20	1957—5.09
1957-58	31	5.64- 5.03	−11	1958—4.53
1958-59	25	5.44- 6.84	+26	1959—5.71
1959-60	19	6.89- 7.00	+ 2	1960—5.82
1960-61	17	6.76- 7.58	+12	1961—6.52
		Bald Eagle Area		
1953-54	5	6.60- 8.40	+27	1954—8.40
1954-55	5	8.40- 7.80	− 7	1955—7.81
1955-56	5	7.80- 5.80	−26	1956—6.13
1956-57	5	5.80- 7.40	+10	1957—6.74
1957-58	5	7.40- 7.00	− 5	1958—6.40
1958-59	4	7.25- 9.25	+28	1959—8.19
1959-60	2	13.00-12.50	− 4	1960—7.86
1960-61	2	12.50-14.00	+12	1961—8.83



TREND IN WOODCOCK BREEDING POPULATION INDEX IN PENNSYLVANIA

Fig. 16



WOODCOCK HARVEST RECORD FOR PENNSYLVANIA

Fig. 17

of woodcock bagged. These data are shown in Table 33.

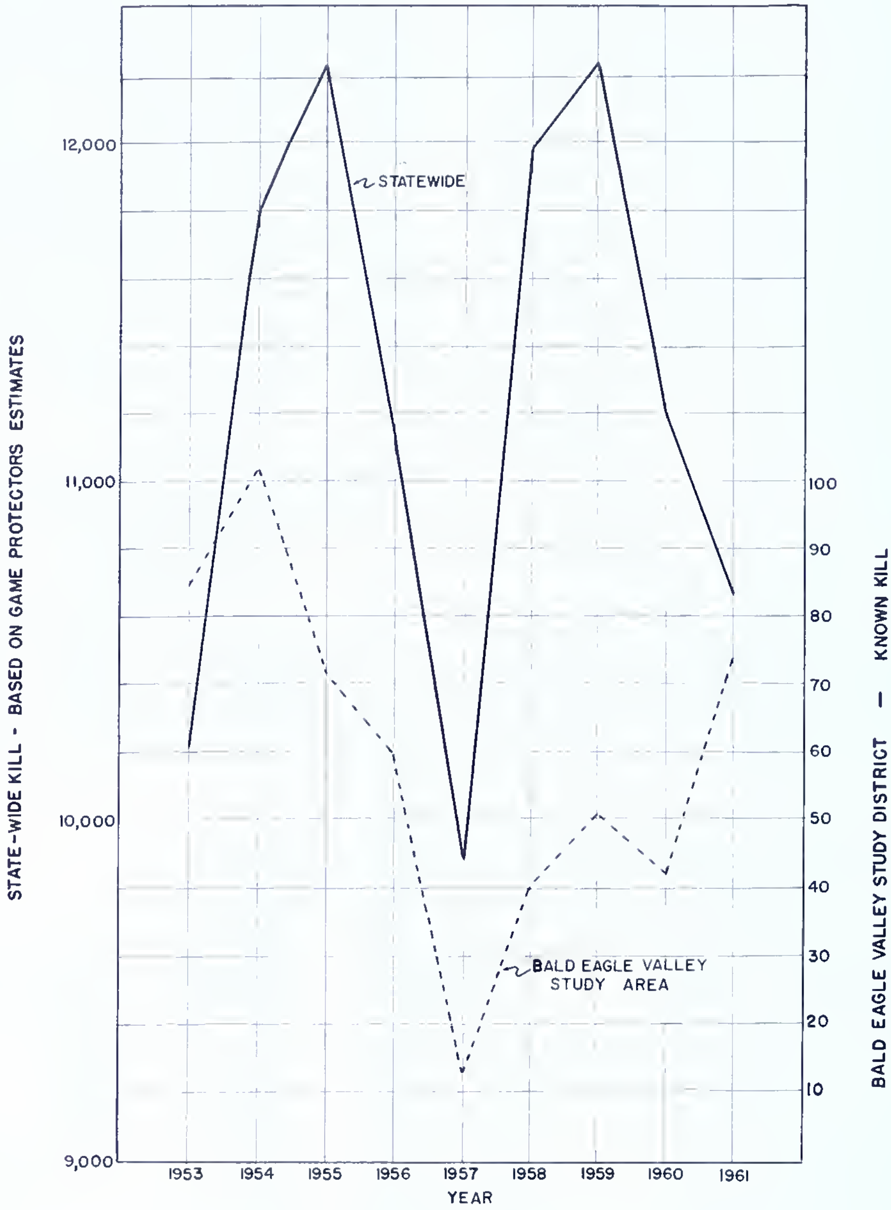
Information given in Figure 17 shows that the woodcock harvest decreased considerably from the 1930s. Since 1950, however, the harvest remained rather stable; i.e., approximately 12,000 woodcock annually. One year, 1957, stands out as an exception. The estimated low kill (9,854) that year was generally attributed to exceptionally dry weather. Central Pennsylvania experienced the driest July and August in 70 years. Woodcock were very difficult to find that fall, re-

TABLE 33

Woodcock Harvest Record for Pennsylvania

Kill based on:

Year	1. Game Protector Estimates State-wide	2. Hunters' Reports State-wide	3. Actual Survey Bald Eagle Area
1931	31,650		
1932	27,141		
1933	30,570		
1934	30,386		
1935	36,856		
1936	25,455		
1937	30,271	57,244	
1938	33,703	50,085	
1939	31,471	40,806	
1940	23,079	29,087	
1941	19,488	31,328	
1942	18,793	27,729	
1943	13,974	15,588	
1944	11,605	16,400	
1945	24,937		
1946	17,042		
1947	20,263		
1948	26,210		
1949	26,748		
1950	17,500		
1951	14,409		62
1952	12,520		68
1953	10,225		86
1954	11,816		101
1955	12,246		72
1956	11,126		55
1957	9,854		12
1958	11,992		42
1959	12,250		51
1960	11,230		42
1961	10,662		74

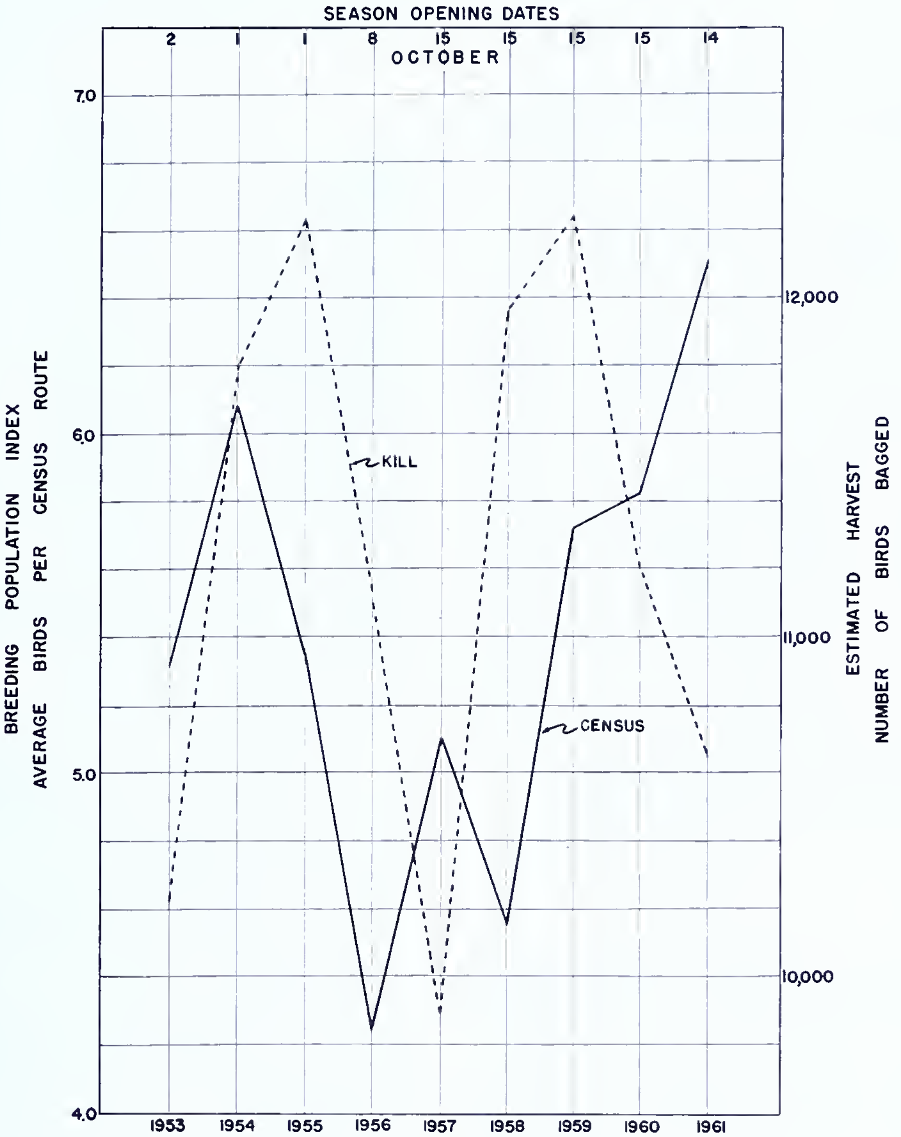


WOODCOCK HARVEST TREND IN PENNSYLVANIA
Fig. 18

sulting in low hunting effort and kill.

Pennsylvania's woodcock harvest is compared with that of other states and Canadian provinces in Table 34. These data do not represent uniform harvest distribution within any state or province.

From 1953 to 1961, a woodcock bag check was conducted on the Bald Eagle Study Area. The data are pre-

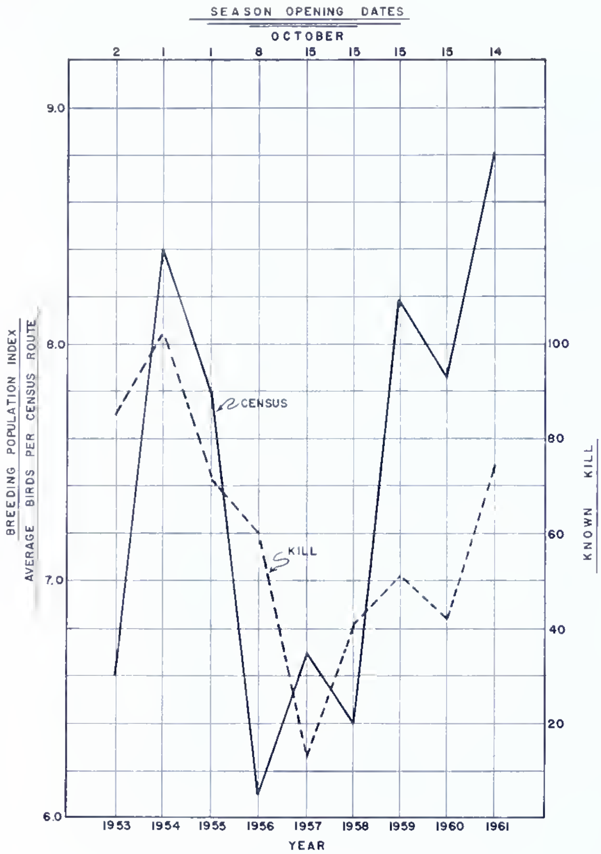


WOODCOCK CENSUS-KILL COMPARISON FOR PENNSYLVANIA

Fig. 19

sented in Figure 18 and are compared with the statewide kill. As was previously found with the breeding population index, the kill trend in the study area likewise reflected that in the estimated statewide harvest.

Figures 19 and 20 compare census data and harvest records. One compares the statewide breeding population index with the statewide kill. The other compares the Bald Eagle study area breeding index with its local kill.



WOODCOCK CENSUS-KILL COMPARISON
FOR BALD EAGLE STUDY AREA

Fig. 20

Trends in both the breeding population index and the harvest record generally were similar.

It is interesting to speculate on reasons for the population and harvest reduction from 1953 to 1956 and the upward trend from 1956 to 1961. Timing of the hunting season could be an important factor. When seasons open early in October, resident woodcock make up a greater proportion of the total bag than when seasons start in mid or late October. By allowing more local birds to escape early hunting pressure, the summer resident population should gradually increase. Eventually the resident population, returns per hunting effort, and total bag should increase. The foregoing data appear to substantiate this theory.

Hunting pressure prior to mid October can be exceptionally hard on local populations for the following reasons: (1) resident woodcock seldom migrate, or move to any extent, prior to mid-October; (2) woodcock from more northern breeding areas rarely migrate across the state before mid-October, thus providing little or no shooting in early October; and (3) the lack of early October open seasons on other game species focuses too much attention on woodcock hunting.

TABLE 34

Woodcock Harvest Data by State and Province

State or Province	Average Annual Estimated Kill (1951-1955)	Square Miles (Land Area) Per Kill
Pennsylvania	12,243	3.6
New Brunswick	3,154	8.6
Maine	18,602	1.6
Massachusetts	13,744	.6
Connecticut	8,588	.6
New Jersey	15,253	.5
Michigan	65,385	.9
Wisconsin	22,085	2.5
Minnesota	6,068	13.0

Management

GENERAL

"Game management is the art of making land produce sustained annual crops of wild game for recreational use." So said Aldo Leopold (1947), the often-heralded father of modern game management. This definition is equally applicable today, and promises to be even more fitting in the future.

Management implies some degree of control. Recent emphasis in game management has been placed on the control of wildlife environment and hunting. The central thesis of this study was to investigate these factors in reference to woodcock. The following discussion presents findings on woodcock management in Pennsylvania.

HABITAT MANIPULATION

Basic Principles and Procedures

To maintain a resident woodcock population, the habitat must be of a type, size, and distribution that will provide a proper environment for breeding, nesting, feeding and resting. These requirements are usually met when an area contains clearings, shrub or low tree coverts, and soil containing an adequate supply of suitable and available food. A brief discussion of these principles follows:

Woodcock need clearings (sites devoid of tall vegetation) to court and mate successfully. Clearings one-quarter acre in size are adequate. Smaller sites are often used, especially when surrounded by low vegetation. Most places have no scarcity of mating fields, and some areas have excess clearings. Management would be enhanced if large fields were divided into smaller openings by hedgerows and clumps of shrubs. When clearings are needed, cutting tools and herbicides can be employed. Techniques of application are discussed elsewhere.

Woodcock require negligible nesting cover. Nests were found in briar patches, shrub thickets, sapling groves and young conifer stands. Nests usually were located near edges of such cover types. Providing nesting cover is no particular problem, since resting or loafing coverts also serve well as nesting sites.

Woodcock commonly spend inactive periods in coverts separated from, or adjacent to, feeding and mating areas. These coverts, usually found on higher, drier ground, are composed of shrub, brush, or low tree-type vegetation. Occasionally good resting sites also are good feeding sites and vice-versa. To insure good year round usage, some low woody vegetation should be present in both the feeding and nesting areas. The usefulness of such coverts depends on the vegetational type and related site factors, but few last more than 30 years. Plant succession plays a vital role. The useful life of coverts can be extended by manipulation of the vegetation. Dormant season cutting plus the use of herbicides is one method of rejuvenating these "worn out" coverts. Shrub plantings can create such habitat when natural invasion is slow or inadequate.

Due to the restricted nature of the woodcock diet, good feeding sites are essential. Best feeding areas are found along streams, tributary runs, and springs. Not all such areas, however, contain good supplies of woodcock food. Floral composition or site location in themselves do not insure good feeding grounds. Some sites may be too acid, too sandy, or too wet, and some may possess a combination of these and other factors inhibiting earthworm production. Rejuvenation of nonproductive areas is much more difficult than maintaining good sites. Invasion of large trees and excessive flooding should be prevented if good feeding sites are to be retained.

Results of various experiments in manipulating woodcock habitat discussed below include planting, cutting, spraying, and grazing.

Planting

An absence of suitable vegetative cover frequently limits woodcock populations in the state. Sites often suitable in soil fertility and earthworm production may be lacking in other requirements. Areas deficient in shrub cover also may have dense mats of herbaceous plants, making it difficult for woodcock to obtain food. Excessively moist abandoned fields are commonly in this category. Many such fields, especially those being invaded very slowly by undesirable plant species, would receive more woodcock use if planted with suitable shrubs. Planting experiments described here were aimed at determining the best methods of producing good woodcock cover on abandoned or "old field" sites.

Many seedling shrubs were tested for their suitability in developing woodcock coverts. The 20,224 seedlings of 7 species planted were selected from stock at the Game Commission nursery. Sixteen old field sites near streams were divided into 388 test plots of varying size. The sites were in Centre, Huntingdon, Indiana, Washington, and Erie Counties. Seedlings planted per individual plot varied from 5 to 400. An attempt was made

TABLE 35

Number of Shrubs Planted by Species and Location

Location of Planting Area	Planting Site No.	Number of Shrubs Planted: Common Alder	Gray Dogwood	Silky Dogwood	Bay Berry	Coral Berry	Black Haw	Arrow-wood	Total
I. Bald Eagle Valley Centre County	1		400	200					600
	2		300	300			100		700
	3	50	268	248			118		584
II. Stone Valley Huntingdon County	4	730	615		100	70			1515
	5	400	600	100	80	100			1280
	6		200		100	100			400
	7	980							980
	8	200	200		30	60			490
	9	480	650	150	550	450			2280
	10	375	500		150	300		350	1675
III. Aultman Run Indiana County	11	500	750			200	400		1850
	12	3700	220		250	250	100		4520
	13	400	600	150	200	200			1550
	14	750			150		100		1000
IV. SGL #101 Erie County	15	200							200
V. Water Co. Land Washington County	16	500							500
Total		9265	5303	1148	1610	1730	818	350	20224

TABLE 36

Shrub Planting Survival Data

Species	Age of Seedlings	Percentage Survival After 2 and 3 Years Average	Range
Common Alder	1-0	8	0- 35
	2-0	18	11- 42
	3-0	36	18- 45
Gray Dogwood	1-0	35	0-100
Silky Dogwood	1-0	36	0- 90
Coralberry	1-0	54	10- 96
Bayberry	1-0	43	6- 88
Black Haw	2-0	65	33-100
Arrowwood	2-0	29	16- 44

to determine effects of various designs and spacing, but insufficient time had passed to detect possible benefits. Propagation by direct seeding and by root and shoot cuttings also was tried. The number of seedlings planted by species and location is presented in Table 35. Establishment success for each species is listed in Table 36.

After intervals of 2 and 3 years, planting sites were inspected to determine seedling survival. Variation in survival existed between species and between plots and sites. Primary reasons for these differences stemmed from diverse site factors and age of the planting stock. The most critical site factor appeared to be soil moisture. These factors and the success of the propagation tests are discussed for individual species.

Alder (*Alnus serrulata*) was by far the most important plant in woodcock habitat, so emphasis was placed on its propagation and management. Information concerning alder propagation was scarce, and seed and planting stock was unavailable from commercial sources. Nevertheless, considerable progress was made.

Seed was collected from local alder thickets and, after much trial and error, seedlings were grown at the Game Commission nursery. Success from field planting varied with the age of the seedling stock. The low average survival (8 percent) of 1-year-old stock was attributed to plant competition when the sod was not scalped and to frost-heaving when the sod was removed. Two- and 3-year-old seedlings did much better. Failure in older stock resulted from droughty soil conditions.

Field propagation of alder by stem and root cuttings was a complete failure. Approximately 300 cuttings of each type were prepared and planted on what was considered an ideal site. Of the few (20 percent) stem cuttings which sprouted none lived through the first season. Tests were discontinued after these initial failures.

More recent tests in alder propagation by direct seeding showed considerable promise. Preliminary tests at the nursery and field observations indicated that alder seed germinated best in cool, moist soil. Field testing was the next step.

A field uncultivated for about 10 years and adjacent to Aultman Run on the Conemaugh River Reservoir, Indiana County, was selected for the experiment. Rows of paired 100-square-foot plots were established along contours 200, 400, and 600 yards from the stream. The soil on half of the paired plots was disked before sowing. A half pint of alder seed was broadcast on a pair of plots on each row at approximately 2-week inter-

TABLE 37

Results of Direct Alder Seeding Related to Sowing Date, Site Location, and Soil Treatment

		Number of Seedlings (9/8/61)								
		Cultivated Plots				Uncultivated Plots				
Plot Number	Date Sowed	Site 1	Site 2	Site 3	Total	Site 1	Site 2	Site 3	Total	Total Plots
1	7/ 1/57	4	0	1	5	1	0	2	3	8
2	7/15/57	0	0	0	0	0	0	0	0	0
3	8/ 1/57	0	0	0	0	0	0	0	0	0
4	8/15/57	4	0		4	0	0	0	0	4
5	8/30/57	33	0	1	34	0	0	0	0	34
6	1/24/58	29	6	2	37	0	1	2	3	40
7	2/14/58	54	30	80	164	0	5	75	80	244
8	2/28/58	6	32	95	133	4	13	95	112	245
9	3/17/58	9	31	85	125	5	11	75	91	216
10	3/31/58	11	28	85	124	4	32	65	101	225
11	4/15/58	9	52	45	106	0	29	18	47	153
12	5/ 1/58	0	28	54	82	0	73	13	86	168
13	5/15/58	0	16	24	40	0	24	0	24	64
14	6/ 2/58	0	1	2	3	0	2	0	2	5
15	6/16/58	0	0	2	2	0	0	0	0	2
16	6/30/58	0	0	1	1	0	1	0	1	2
17	7/15/58	0	0	1	1	0	0	0	0	1
18	7/30/58	0	0	2	2	0	0	1	1	3
19	8/14/58	0	0	0	0	0	0	0	0	0
20	9/ 2/58	0	0	2	2	0	0	0	0	2
21	9/15/58	0	0	1	1	0	0	0	0	1
22	9/30/58	0	0	0	0	0	0	0	0	0
23	1/ 2/59	0	0	3	3	0	0	0	0	3
24	1/16/59	0	0	0	0	0	0	0	0	0
25	2/ 2/59	0	0	5	5	0	0	0	0	5
26	2/16/59	0	0	1	1	0	0	0	0	1
27	3/ 4/59	0	0	1	1	0	0	2	2	3
28	3/17/59	0	2	6	8	4	0	2	6	14
29	3/31/59	0	2	17	19	0	0	2	2	21
30	4/15/59	0	1	6	7	0	1	4	5	12
31	5/ 1/59	0	0	22	22	2	8	19	29	51
32	5/20/59	1	12	37	50	0	1	17	18	68
33	6/ 1/59	1	2	25	28	0	0	9	9	37
34	6/16/59	0	0	12	12	0	1	9	10	22
35	7/ 8/59	0	2	5	7	0	0	4	4	11
36	7/15/59	0	0	2	2	0	0	0	0	2
37	8/18/59	0	0	1	1	0	0	0	0	1
38	8/31/59	0	2	0	2	0	0	1	1	3
39	9/15/59	0	5	0	5	0	0	0	0	5
40	10/ 1/59	0	5	0	5	0	2	0	2	7
41	10/22/59	0	7	0	7	0	0	0	0	7
42	11/12/59	0	3	0	3	0	0	0	0	3
43	1/ 1/60	0	2	2	4	0	1	0	1	5
44	1/15/60	0	4	3	7	0	0	1	1	8
45	4/ 8/60	0	8	0	8	0	1	1	2	10
Total	Site 1	161				20				181
Total	Site 2		281				206			487
Total	Site 3			631				417		1048
	Total				1073				643	1716

vals throughout the year. No special attempt was made to cover the seed, but raking and walking over the plot were used to place the seed next to the mineral soil. Sowing dates and the number of seedlings which sprouted on each plot are shown in Table 37. Success of seeding tests as related to month of sowing and pre-sowing soil treatments are presented in Table 38.

Several conclusions can be drawn from the data. First, prepared seed beds produced 35 percent more seedlings than untreated plots. This could be an important factor if seed cost is high. Second, sites closest to the stream produced the most seedlings. A third, and very important, factor was the effect of sowing date on the success of seedling establishment. February and March were the best months for sowing alder seed. This generally was true regardless of soil treatment or site location.

The following data pertaining to alder seed were developed while experimenting with alder propagation.

1. Time required to collect seed:
   (a) When seed is plentiful:
   One hour to pick 4 gallons of cones, which produced 1.6 lbs. or 3.2 quarts of seed.
   (b) When seed was scarce:
   One hour to pick 1 gallon of cones, which produced .4 lbs. or .8 quarts of seed.
2. Volume of cones required to produce 1 pound of seed, 2.5 gallons.
3. Purity of seed, variable (60 to 90 percent).
4. Soundness of seed, variable (30 to 60 percent).
5. Germination capacity of seed, variable (2 to 60 percent).
6. Yield per pound of seed: Volume, 2 quarts; total number, 300,000; number of sound seed (based on 30 percent soundness), 90,000.

Note: All references to seed quantity include 40 percent impurities.

Gray dogwood, *Cornus racemosa*, is a very important shrub in woodcock habitat. Some success was realized from planting one-year-old stock, but the percentage survived (0-100) varied considerably between planting sites. Success was definitely better on more

TABLE 38

Results of Direct Alder Seeding Related to Month of Sowing and Soil Treatment

Month of Sowing	Number of Plots			Total Number of Seedlings			Average Number of Seedlings per Plot		
	C	U	Total	C	U	Total	C	U	Total
January	15	15	30	51	13	64	3.4	.9	2.5
February	12	12	24	303	193	496	25.3	16.0	20.7
March	15	15	30	277	192	469	18.5	12.8	15.6
April	9	9	18	121	54	175	13.4	6.0	9.7
May	12	12	24	194	158	352	16.2	13.2	14.7
June	15	15	30	46	22	68	3.1	1.5	2.3
July	18	18	36	17	8	25	.9	.4	.7
August	18	18	36	41	1	42	2.3	.1	1.2
September	4	4	8	8	0	8	2.0	0	1.0
October	2	2	4	12	2	14	6.0	1.0	3.5
November	1	1	2	3	0	3	3.0	0	1.5
Total	121	121	242	1073	643	1716	8.9	5.3	7.0

C—Cultivated (disked) plots. U—Uncultivated plots.

CLEAR-CUTTING, release cutting and thinning were evaluated as habitat management practices.

fertile soils, and where sod was removed before planting. On some sites, where survival was low and growth rate slow, it appeared that more aggressive natural invaders would dominate the site.

Silky dogwood, *Cornus Amomum,* another common plant associate in woodcock habitat, grew on a wider variety of sites than gray dogwood. Seedlings exhibited greater than expected tolerance for dry sites. Scalping the sod prior to planting also aided in survival. Unlike silky dogwood, gray dogwood, once established, persisted and spread better on the drier sites.

Black haw, *viburnum prunifolium,* is a locally common plant in some woodcock coverts. The average survival rate of test plantings was exceptionally high (65 percent) exceeding all other species. It also was tolerant to a wide variety of sites. In comparison to other plants tested, black haw was heavily browsed by rabbits, deer and cattle. Nevertheless, it persisted, even though badly deformed.

Arrowwood, *Viburnum dentatum,* was not adequately tested. Limited observations precluded any conclusions. The data are presented as a matter of record.

Coralberry, *Symphoricarpos orbiculatus,* while a non-native and not a particularly good species for woodcock habitat, was readly available at the Commission nursery for testing. It grew well on a wide variety of sites, but did best on more fertile soils with some shade. Sod scalping hindered rather than aided establishment.

Bayberry, *Myrica pentsylvanica,* was another questionable but readily available exotic species. Success was poorest on extremely wet or dry soils, best on moist soils. Although growth rate was slow, vigor of the stock remained excellent. Establishment success varied little between scalped and unscalped plots.

Studies of propagation should be continued with the most promising species. In addition to alder, gray dogwood and black haw, native hawthorns and autumn olive also should be investigated.

The establishment of woodcock coverts by shrub plantings appeared to have definite possibilities. If woodcock coverts do not become established on abandoned fields through natural succession and minimum cultural practices (culling undesirable invaders by cutting, spraying, etc.),

CONCENTRATIONS of several herbicides were tested to evaluate spraying as a possible tool for the manipulation of habitat.

then planting may be justified. Species control and arrangement can be achieved by judicious planting, but may be more costly.

Cutting

Cutting was one of the best methods of rejuvenating and maintaining woodcock habitat. Three types found to be useful were clear-cutting, release cutting and thinning.

Clear-cutting refers to the complete severance of all woody stems. This method was used to create singing grounds and to rejuvenate stands of alder and aspen. Such experimental cutting proved quite successful for these purposes. Cost of clear-cutting varied considerably, due to the type, size and density of vegetation, as well as accessibility of the stand. These differences became apparent during cutting experiments. From 30 to 60 man-hours were required to fell and limb an acre of trees and/or brush. Removal of stems from the plots involved an additional 15 to 30 hours per acre.

Release cutting generally was employed when woodcock coverts were being dominated by large trees, and where there was still a remnant stand of shrubs. The removal of overstory trees such as elm, red maple, white ash, and black cherry permitted resurgence of small tree or shrub species.

Release cutting to improve a deteriorated woodcock covert was tested in the Stone Valley Experimental Forest, Huntingdon County, on a 3-acre site located along a small stream. This involved felling 256 trees of 2 to 36 inches in diameter. All trees (173) above 6 inches in diameter (D.B.H.) were removed from the site and converted into pulpwood and fence posts. According to the Southern Hardwoods Table of Specifications, approximately 30 cords of wood could be produced from the volume removed. Additionally, stumps were chemically treated to prevent resprouting. Details of herbicide use are given under the section on "Spraying."

TABLE 39

Results of Basal Application of Herbicide* to Hawthorn and Crab Apple

	Number of Stems: Size Class (inches D.B.H.)					Percent of Total
	0-2	3-4	5-6	7-8	Total	
Hawthorn						
1. Treated	16	34	11		61	
2. Killed	14	28	7		49	80
3. Partly killed	2	4	3		9	15
4. Not affected	0	2	1		3	5
	32	68	22		122	100
Crab Apple						
1. Treated	4	19	27	15	65	
2. Killed	4	15	19	10	48	73
3. Partly killed	0	3	5	4	12	19
4. Not affected	0	1	3	1	5	8
	8	38	54	30	130	100

**2,4,5-T Butoxy Ethanol Ester; 4 lbs. acid equivalent per gallon.*

Approximately 178 man-hours were spent on this experiment. Time distribution was as follows:

Job	*Setting-Up*	*Man-hours: Actual Work*	*Total*
1. Reconnaisance and marking	3	3	6
2. Felling and limbing	6	95	101
3. Skidding logs	4	47	51
4. Spraying stumps	4	16	20
	17	161	178

A time study, involving 2.5 acres, also was conducted on the Conemaugh River Reservoir, Indiana County. However, this flood control property and slash had to be disposed of to prevent floating into the reservoir during high water. Burning was the most feasible alternative. The data are presented for comparison.

Job	Setting-Up	Actual Work	Total
1. Preliminary surveys	3	0	3
2. Felling, limbing and burning	4	130	134
3. Skidding logs	4	54	58
4. Spraying stumps	1	5	6
	12	189	201

Results of all release cuttings were encouraging. Five years after treatment these sites were almost completely dominated by shrubs and small tree saplings, whereas only about 30 percent of the area contained such cover prior to treatment. Alder, blue beech, gray dogwood and hawthorn responded well to overstory removal.

While thinning has limited use in woodcock habitat, this technique is applicable in places such as crab apple and hawthorn thickets. Thinning of these vegetational types improves soil conditions and promotes earthworm production.

This practice was tried in dense stand of crab apple and hawthorn. Oldest stems were approximately 50 years old, while the average was about 25. Less than 5 percent of the ground was covered with herbaceous vegetation, and there were approximately 3 earthworms per cubic foot of soil. Apparently the dense crown canopy prevented sunlight from reaching the soil surface. This, in turn, restricted the amount of undergrowth, organic matter, earthworms, and woodcock usage.

Stands were divided into parts to compare thinning methods. One portion, .15 acres in size, was thinned by cutting, and the other, .22 acres, was thinned by an herbicide. On the first plot 50 percent of the trees were felled and removed, on the second 60 percent were chemically treated and left standing. The herbicide, 2,4,5-T (acid equivalent 4 lbs. per gallon), diluted in fuel oil at the ratio of 1 to 25, was applied to the basal 18 inches of selected trees. Enough solution was applied to saturate the bark.

Six years following treatment the cut-over and chemically treated plots contained 90 and 60 percent herbaceous cover, respectively. The number of earthworms increased to an average of 22 per cubic foot in the cut-over plot, and to an average of 10 in the chemically treated plot. Only 10 percent of the chemically treated stems showed signs of life at the end of 6 years. Results of the herbicide treatment of hawthorn and crab apple are given in Table 39.

Spraying

The use of chemical agents in controlling vegetation has recently received much attention. New chemical formulations and methods of application are rapidly developing. Their use in game habitat work is certainly worth consideration. The value of herbicides in manipulating woodcock habitat was studied. There are three generally accepted methods of spraying herbicides on vegetation; i.e., on the foliage, on the basal portion of the stem, or on the stump. Each method has been tried in woodcock habitat with varying success.

Experimentation with foliage spraying for the development and maintenance of woodcock habitat was limited to abandoned fields supporting a dense growth of tall, climbing, non-woody vegetation. It was originally believed that chemical foliage sprays might have somewhat the same beneficial effect as cattle grazing. A study was initiated in an area where such conditions prevailed. A series of one-hundredth-acre plots was established and sprayed with several concentrations of both 2,4-D Ester and 2,4-D Amine (Table 39). Each plot received an equal volume of the solutions.

As may be seen in Table 39, the stronger the concentration of herbi-

TABLE 40

The Effect of Three Concentrations of Two Forms of 2,4-D Herbicide on Wild Plants*

	Degree of Effectiveness**—By Mid-September, 1952											
	Application Date: 5/30/52 Treatment:***						Application Date: 7/30/52 Treatment:					
Plant Species	1	2	3	4	5	6	1	2	3	4	5	6
Virgin's Bower	F	G	G	F	F	G	P	P	F	P	P	F
Black Bindweed	G			G			G	G		G		G
Grass (Panic)	N	N	P	N	N	P	N	P	F	P	F	F
Grass (Others)	P	P	P	N	P	F	F		F	P		F
Sedges	P	F			P	F						
Goldenrod	G	G	G	F	F	G	F	F	G	F	F	G
Rough Bedstraw		P	G	P	F	F	F	F	F	F		
Curled Dock	G	G	G	F	F	F	G				G	F
Turk's Cap Lily	G	G			G	G			G			
Violets		F					F		F	F		
Yellow Wood Sorrel	G	F		F		F					F	
Skunk Cabbage		G		G	G							G
Smartweed	G			F	F		G					G
Joe-Pye-Weed			G			G	G	G		G		
Jewelweed	G		G	G		G	G	G	G	G	G	G
Arrow-Leaved Tearthumb	G		G								G	G
Jerusalem Artichoke	G	G		G	G	G	P	F		F	F	G
Blackberry	F			P	G	F						
Virginia Creeper					F					G		G
Silky Dogwood	G	G	G	G	G	G	F	F	F	G		G
Buttonbush	P								P			P
Black Willow		G	G	F						G		
Common Alder								F	F	G	F	

*Plants present on more than one-quarter of plots.

***Treatment: Solution strength (parts water to 2,4-D) and form used: 1. 13-Amino-Alkanolamine salt formulation. Contains 4 lbs. 2,4-D acid equivalent per gallon. 2. 17-Amino-Alkanolamine salt formulation. Contains 4 lbs. 2,4-D acid equivalent per gallon. 3. 80-Amino-Alkanolamine salt formulation. Contains 4 lbs. 2,4-D acid equivalent per gallon. 4. 13-Ester-Ethyl ester formulation. Contains 3 lbs. 2,4-D acid equivalent per gallon. 5. 17-Ester Ethyl ester formulation. Contains 3 lbs. 2,4-D acid equivalent per gallon. 6. 80-Ester-Ethyl ester formulation. Contains 3 lbs. 2,4-D acid equivalent per gallon.

**Degree of effectiveness (kill): N—None, P—Poor, F—Fair, G—Good.

TABLE 41

Number of Stumps Sprayed by Species and Size Class

Size Class D.B.H.	Species							
	Elm	Ash	Maple	Hickory	Cherry	Basswood	Oak	Total
2	17	3	2	1	1			24
4	35	15	7	2				59
6	49	9	8	2	1	2	1	72
8	29	1	4	2				36
10	16	1	3					20
12	11							11
14	9							9
16	6							6
18	4							4
20	4	1						5
22	3							3
24	3							3
28	2							2
34	1							1
36	1							1
Total	190	30	24	7	2	2	1	256

cide, the greater the kill. The ester formulations had a greater decimating effect than the amine formulation. Plants such as virgin's bower, joe pye weed, jewelweed, Jerusalem artichoke, and goldenrod were easily killed; whereas panic and other grasses and sedges were more resistant. During the growing season following treatment, wild rye completely replaced virgin's bower and artichoke on one plot. This replacement, however, was only temporary. And so it was on other plots where the better grasses and low herbaceous plants temporarily replaced the original types. After a few years practically all of the plots reverted to their original floristic composition. This practice was considered impractical as a tool in manipulating herbaceous vegetation for woodcock habitat.

Five years later cattle were pastured in the area. After two grazing seasons of three months each, 18 dairy cows practically eliminated the tall herbaceous vegetation. The site was temporarily more attractive to local woodcock. Two years later the site apparently was over-grazed for optimum woodcock habitat.

Foliage sprays also were used in alder thickets. Alder was easily top-killed by a 4 percent dilution of 2,4-D in water. Basal sprays can be used effectively to thin stands of woody plants when there is no objection to leaving the dead stems standing. Basal spraying was very effective in killing alder. This process can be used to advantage in selectively culling other undesirable woody plants. Generally, 2,4,5-T (4 lbs. per gallon, acid equiv.) proved most effective for basal spraying, although 2,4-D can be used on highly susceptible vegetation.

Spraying freshly cut stumps with herbicides is a promising method of manipulating woodcock habitat. It is a quick and easy way of creating woodland clearings retarding growth of undesirable plants. Much experimentation with this method was undertaken during the investigation.

This technique was used to create permanent clearings in woodland hab-

TABLE 42

Results of Spraying Stumps with Six Esters of 2,4,5-T Herbicide

					Survival (One Year After Spraying)			
Plot No.	Chemical Acid Equiv. 4 lb./gal.	Treatment*	Basal Area (Sq. Ft.) All Species	Species	Stumps Living	Stumps Dead	Dead Stumps With Living, Exposed Roots	New Sprouts
1	2,4,5-Trichlorophenoxy acetic acid. (Propylene glycol butyl ether ester)	1	6.35	Elm	0	12	0	0
				Red Maple	0	2	0	0
				Hickory	0	1	0	1
2		2	9.12	Elm	0	22	0	0
				White Ash	0	2	0	0
3		3	16.14	Elm	0	10	1	0
				White Ash	1	3	0	5
				Black Cherry	0	2	0	0
				Hickory	0	1	0	0
				Red Maple	0	2	0	0
4	2,4,5-Bep-Ester (Butoxy ethoxy propyl ester)	1	7.74	Elm	8	17	3	0
				White Ash	0	1	0	0
				Red Maple	1	3	0	0
				White Oak	0	1	0	0
5		2	5.26	Elm	0	11	4	0
				White Ash	0	2	0	0
				Red Maple	0	4	1	0
				White Oak	1	0	0	0
6		3	19.20	Elm	1	14	5	0
7	2,4,5- Eep-Ester (Ethoxy ethoxy propyl ester)	1	4.78	Elm	2	8	5	0
8		2	5.11	Elm	0	14	2	0
				White Ash	0	1	1	0
9		3	19.16	Elm	0	13	10	0
				White Ash	1	1	0	3
				Hickory	0	3	0	0
10	2,4,5-Trichloroacetic acid and 2,4 Di-chloro phenoxy acetic acid	3	11.58	Elm	0	21	16	0
				White Ash	2	12	6	0
				Basswood	0	1	1	0
11	2,4,5-Trichlorophenoxy acetic acid (Isooctyl ester)	3	13.46	Elm	2	14	7	0
				White Ash	1	6	5	0
				Red Maple	1	1	1	0
				Black Cherry	0	1	0	0
12	2,4,5-Trichlorophenoxy acetic acid (Butoxyethoial ester)	3	12.22	Elm	0	17	4	0
				White Ash	1	4	2	0
				Red Maple	0	5	3	0
					22	233	77	9

**Treatments: 1. Sprayed on top and around unfrilled base. 2. Sprayed on top and in frill. 3. Sprayed in frill only.*

Note: One and one-half gallons of solution (1 part herbicide, 24 parts kerosene) were applied in each treatment.

IDEAL ALL SEASON woodcock habitat in Pennsylvania showing openings for courtship and mating, "edges" for nesting and streamside coverts for feeding and resting.

itat. Such clearings are important to woodcock breeding success. They also provide good feeding areas for turkey and grouse broods. To create such clearings all woody plants were severed and removed from the plots. Then the cut surface, or stumps, of all stems were sprayed with 2,4,5-T and fuel oil (4 percent 2,4,5-T by volume). Respraying was necessary for the more tolerant species.

Stump spraying with herbicides also was used in conjunction with release cuttings on the Stone Valley Experimental Forest. Six different esters of 2,4,5-T were applied to the freshly cut stumps to compare their effectiveness in preventive sprouting. Three methods of application tried were:

1. Spraying the top and around the un-frilled base of the stump.
2. Spraying the top, a ring of frills, and all exposed surfaces below the frilling.
3. Spraying the frill portion only.

Treated stumps were checked one year later. Of 255 stumps treated, only 22 remained alive. Of the 233 dead stumps, 77 had living exposed roots and only 9 new sprouts. Differences in the effects of various chemical agents and results of the three methods of application are shown in Tables 40, 41 and 42. Spraying stump tops and the frill were the most effective methods.

Stump spraying of alder was as effective as basal spraying; i.e., practically all stumps were killed. A little sprouting occurred from exposed living roots, possibly from an adjacent stand.

Grazing

Depending on the intensity of cattle grazing in woodcock habitat, effects can be beneficial or detrimental. Observations were made in the Bald Eagle Study district where examples of both kinds of grazing occurred. However, no intensive study of detailed factors was undertaken.

One 16-acre tract of thick bottomland cover ungrazed for 10 years was grazed in 1952. By the end of the first grazing season (8 steers for 120 days) the habitat appeared much improved and woodcock seemed attracted to it. More woodcock were harvested from this site than from an adjacent ungrazed site of similar floristic composition that season. The same situation prevailed the following year when 7 heifers grazed there for about the same time. But after three years of this treatment the site appeared overgrazed, and woodcock utilization shifted to the ungrazed portion. During the next five years grazing at this intensity the site was not as attractive to woodcock as the adjacent area.

In conclusion, it is recommended that bottomland woodcock habitat not be subjected annually to more than 25 animal days of grazing per acre. A grazing day constitutes one head for one day. Additionally, woodcock would benefit if the site were left completely ungrazed at least one year out of every five.

MANAGEMENT OF SPECIFIC COVER TYPES

Woodcock habitat may be made up of several rather well defined vegetative types, each of which has certain silvicultural characteristics. These must be considered when managing for a specific covert.

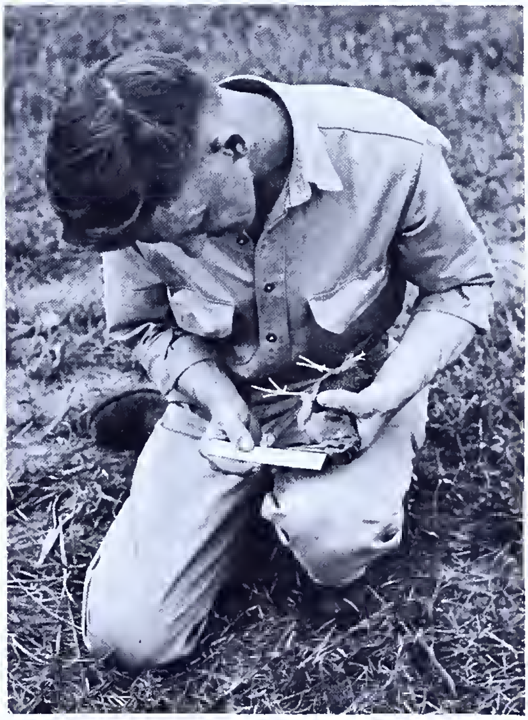
Alder

Alder coverts can be established by planting seedlings or by direct seeding. Two- or three-year-old seedlings were the best size. Scalping the sod prior to planting was helpful, but not essential. If direct seeding is used, fall-collected seed should be sown the following February or March. Disking the planting site prior to sowing reduces the amount of seed required by approximately 40 percent. However, good results were realized from sowing directly into sod. Both direct seeding and planting were most successful on cool, moist sites.

Mature and over-mature alder stands can be rejuvenated best by clear-cutting during winter. Tall trees invading the stand should be cut at the same time and their stumps treated with an herbicide. One part 2,4,5-T, having an acid equivalent of 4 pounds per gallon, to 25 parts fuel oil or kerosene is recommended for stump spraying. Care should be taken not to spray alder, which is rather easily killed by herbicides. Extensive alder stands can be managed on a rotation basis, i.e., a portion can be cut every four or five years. A complete cutting cycle should span approximately 25 years. Several stages of growth will then be present at all times and renewal of the stand insured.

Alder management also is important because this shrub has the ability to fix nitrogen, an important element in plant growth. This should interest farmers who wish to maintain soil fertility of idle acres and also practice good game management.

BILL LENGTH measurements were taken to determine the sex of the birds trapped during the study.



JUVENILE BIRDS were banded to seek information about young birds and their movements.

Aspen

Aspen, another important habitat type, is relatively intolerant to shade and needs practically full sunlight to grow and reproduce. The land manager must consider this in planning. If it is not desired to maintain an aspen stand, other species may simply invade the site through natural succession. On the other hand, if management requires perpetuation of aspen, clear-cutting is essential.

Frequency of cutting depends on several factors, such as quality of the site and timber, market demand, accessibility, and the purpose of cutting. A cutting rotation of 20 years could benefit woodcock, but would be of limited value to the wood-using industry.

Several practices can be used to rejuvenate decadent aspen stands. If the stand is open enough, heavy disking prior to clear-cutting stimulates sprout suckering. Other more tolerant species competing for the site also should be cut and stump-sprayed with an herbicide as previously described. If there is no objection to leaving competing trees standing, they can be killed by basal application of herbicides.

Hawthorn

The value of native hawthorns as game habitat has long been recognized. This is true not only for woodcock, but also many other game species. Consideriing the value of hawthorn, it is unfortunate that little is known about its propagation and management. Recent studies by and under the direction of Dr. W. M. Sharp, former Leader of the Cooperative Wildlife Research Unit at Pennsylvania State University, contribute substantially to our knowledge of the species. This work has been reported in part by Hoover (1961).

The limited studies of hawthorn propagation and management make recommendations difficult. However, dense stands generally can be improved by selective cutting of inferior species, by removing competing tall trees, and by thinning. Hawthorns are rather intolerant to shade, and do not survive in mature forests with a closed canopy.

Gray Dogwood

Gray dogwood, like hawthorn, also is a valuable native shrub. Its ability to grow on diverse sites and to annually produce good crops of highly preferred fruit is exceeded by few shrub species.

Fair success was obtained from planting seedling stock and some progress made in propagation by direct seeding. Removal of sod before planting seedlings proved beneficial. Although quite adaptable to a wide variety of sites, gray dogwood does best on more fertile soils. Sufficient data are not available to make recommendations on direct seeding.

Gray dogwood thickets respond well

to release cutting. In experimental cuttings where all overhead cover was removed, gray dogwood stems increased 60 percent in 3 years. On an adjacent area where no release cutting was made, stem numbers increased by only 20 percent during the same period.

Fields

Under certain conditions woodcock cover can be created in open fields by establishing shrub communities through planting seedlings or by direct seeding. Certain plant species are more suitable than others. Alder, gray dogwood and black haw were most satisfactory. Others like hawthorn and autumn olive should be tried.

Techniques of propagating alder and gray dogwood have been described. Black haw plantings, like alder or gray dogwood, did exceptionally well on a wide variety of sites.

Planting patterns should be given consideration. Rows 20 feet wide and/or clumps 50 feet in diameter were adequate. Smaller stands often suffice, and serve as a nucleus for natural expansion. At least 100 feet should be left between rows and clumps to allow for expansion and edge effect. Solid plantings of extensive acreage should be avoided.

Other Types

Other important but less frequently occurring plant species found in good woodcock habitat include a willow, sumac, blue beech, silky dogwood and gray birch. Often occurring as small pure groups within a covert, they contribute much to the overall value of the woodcock's natural environment. These species can be maintained by cutting at approximately 20-year intervals, and by preventing the invasion of tall trees.

Some coverts appear floristically to be prime habitat, but are seldom if ever used by woodcock. Floristic composition alone does not insure woodcock usage. Usually the problem is one of improper soil conditions—too acid, too wet, or too sandy—which seriously limit the woodcock's favorite food, earthworms. There conditions are difficult to correct. Perhaps draining, clear-cutting followed by cultivation and planting, or removing and/or replacing the soil would help. These practices appear impractical at present, but, with growing demands on land use, may be of future value. The point made here is that it is much easier to maintain good habitat already in existence than to allow it to degenerate while working on such problem areas. These problem areas may be more suitable for other purposes.

HABITAT MANAGEMENT PLANNING

Procedure

Assuming that the Land Manager is well versed in basic woodcock habitat requirements, he should first prepare a detailed cover map of the area under consideration. After delineating various habitat components the manager must then decide what should and can be done in each vegetational type to improve conditions for woodcock. Specific treatments such as cutting, spraying, etc., would be governed by the desired results. The habitat management plan developed by this study for part of State Game Lands No. 187, Luzerne County, serves as an illustration.

A Woodcock Habitat Management Plan

The following Woodcock Habitat Management Plan was developed and activated on State Game Lands No. 187, Luzerne County, Pennsylvania.

Investigations of State Game Lands No. 187 and surrounding territory showed that portions needed habitat

BANDING STUDIES INDICATE resident woodcock seldom migrate before mid-October. Often the largest groups of migrating woodcock were observed after mid-November.

improvement for woodcock. Once a favorite for woodland bird hunters, it later offered only mediocre sport. This was largely an effect of natural changes in habitat. Plant succession had reached the young forest stage and shrub communities were giving way to more tolerant and longer-lived tree species.

It was believed that through management this process could be retarded and that portions of the area could be restored to their former productivity for woodcock. Other species of woodland game also might benefit from the proposed habitat management practices.

Basic requirements of woodcock habitat were first reviewed to analyze primary vegetational types existing on the area. To facilitate analysis, a cover map and work plan were prepared. Several oak types occurred on the area but all were essentially in the white oak group. On the lower slopes white oak stands also had scarlet oak, red maple and aspen as common associates. On the middle slope, red oak and red maple also were common. A few small ridge tops contained mixed white oak, red oak and chestnut oak. This type was largely confined to southern exposures.

Practically all oak stands were in the small pole stage, four to eight inches diameter at breast height (4½ feet off ground), and were of little value for either game production or timber harvest. Conversion of this largely even-aged forest into several age classes by a well-planned cutting cycle was deemed necessary to improve game conditions. Well-placed clearings and border cuttings in this type would improve conditions for woodcock.

Northern hardwoods were located in the middle and upper slopes of northern exposures. They were poorly situated for woodcock habitat and could be more advantageously managed for timber and large game species. However, on lower slopes where northern hardwoods mix with aspen, considerable benefit could accrue to woodcock from certain cultural treatments. For example, clear-cutting at strategic locations would favor intolerant species such as aspen, red maple and cherry and prevent site domination by the more tolerant sugar maple, beech and birch. At the same time cutover areas would be attractive to woodcock.

The scrub oak type on the management area was beneficial to woodcock and other game. Relatively small in size, it provided good nesting and resting cover for woodcock and food for other game. The stand could be perpetuated for this reason.

Aspen on the management area generally was mixed with northern hardwoods and to a lesser extent with oaks. Unless some of this mixed type was clear-cut, aspen would eventually give way to longer-lived, more tolerant species. Young aspen stands properly located are of considerable value to woodcock.

The narrow band of hemlock in the area provided good winter cover for other game species and should be maintained. Little benefit, if any, would result from changing this type.

Open areas served a useful purpose and should be maintained. These clearings not only provided good mating sites for woodcock, but also furnished good insect feeding areas for grouse and turkey poults.

Shrub areas included alder, gray dogwood, silky dogwood, blue beech and other shrubs. This type was the most important to woodcock. It harbored the best woodcock food source and provided nesting and resting cover. Current shrub areas should be preserved in their entirety and some effort made to expand them.

The plan of woodcock habitat management for this area was one of converting and/or keeping existing cover types in clearings, shrub areas, and young aspen stands. Recommended locations for these operations are shown on Figure 21. Methods of producing the desired results are given below.

Establish clearings by removing all woody plant growth and spray stumps with herbicides. Clearings should be approximately ¼ acre in size or about 100 feet in diameter. Clearing edges should be border-cut back for a 20-30-foot width. Only large trees should be cut on the border and these need not be removed. If shrubs and small trees occur in the border, their growth and spread can be enhanced by spraying the stumps of the larger trees. One part 2,4,5-T having an acid equivalent of 4 pounds per gallon to 25 parts of fuel oil or kerosene is recommended for spraying fresh stumps. A "touch up" spray is sometimes required a year or two after the initial treatment to completely kill more resistant species.

There are several approaches to improving shrub growth. Existing shrub thickets reaching maturity or in decadent condition should be clear-cut during dormancy. Where shrubs are in good vigor, but suppressed, removal of competing large trees will also help. Competing trees can simply be killed and left standing where it is not necessary or feasible to cut them.

Shrub thickets also can be established by planting. Alder, gray dogwood and black haw are recommended. Two- or 3-year-old seedlings should be used.

Aspen stands should be kept in sapling or small pole stage growth to be of maximum value to woodcock. To insure adequate aspen regeneration, clear-cutting is essential. Dormant season cutting produces better results than growing season cutting.

Aspen cut for the market requires additional considerations. For example, a longer cutting cycle would be more desirable. Sites growing the better aspen might be reserved for this purpose. If summer cutting is necessary to facilitate marketing, stump spraying of associate tree species would help to regenerate the aspen. The aspen regeneration provides favorable habitat for woodcock populations.

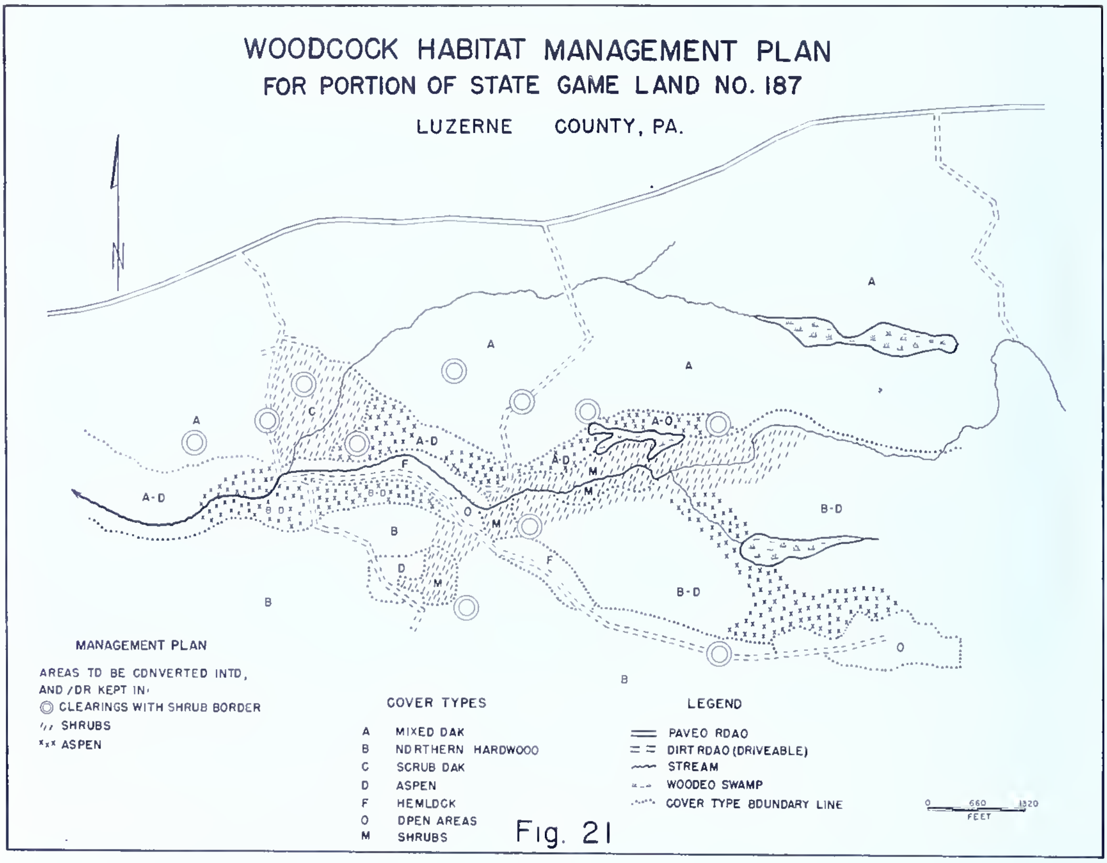


Fig. 21

HUNTING REGULATIONS

Hunting Seasons

Hunting is an important factor limiting resident woodcock populations in Pennsylvania. This is especially true when seasons are set prior to fall migration and when habitat is restricted. It was formerly thought that practically all woodcock bagged during the hunting season were migrants from northern states and provinces, and that resident birds moved out earlier. Banding studies and field observations show that this is not necessarily true. Apparently resident woodcock seldom migrate or move to any great extent to mid-October. Native woodcock are often among the last to migrate.

Late September and early October hunting, therefore, is highly dependent on local stock. Additionally, an early closing date, prior to November 10, prevents the shooting of late, and very often the largest, groups of migrating woodcock.

Indications over five seasons (1957 to 1961) when the season opening date was set back to mid-October, were that the resident population was increasing. It is, therefore, recommended that this opening date be maintained until a change is considered beneficial. Serious consideration also should be given to start the grouse season at the same time as the woodcock season.

Area Restriction

Consideration should be given to additional shooting restrictions in special areas. This would apply only to coverts where the resident woodcock population has been reduced far below its carrying capacity by excessive gunning pressure. This happens most frequently when woodcock habitats are small and somewhat isolated, but it can occur over large areas. Studies show that three to five years of complete protection are required for a population to noticeably increase.

The size of these areas would depend on the manner of administration. Small areas, a few hundred or thousand acres, could be controlled by posting; larger areas, such as townships or counties, might better be handled by special regulation. Such areas should be very carefully selected, hunting restrictions extended from three to five years, and *only* woodcock be protected (i.e., allow other types of hunting). If, during this time, recovery is not evident, other limiting factors would appear to be of more importance. These areas may be of value as bird dog training grounds. Numerous requests for this use were received from grouse and woodcock hunters. Certainly this phase of woodcock management needs additional investigation.

OTHER MANAGEMENT CONSIDERATIONS

Transplantation

The transfer of game animals from well stocked to poorly stocked or uninhabited range is an accepted management technique. In some instances the practice is beneficial. Under special circumstances, this procedure probably could benefit woodcock. If, for example, female woodcock were restricted to certain "singing fields" (by temporary pinioning), it may be assumed that mating would take place. This thesis presumes that the habitat can support more woodcock and that the male is polygamous. If successful, this procedure would rapidly increase a local woodcock population.

SPORTSMEN SHOULD be informed on the effect of habitat, hunting and other elements on woodcock populations.

Although this technique was not fully tested, some progress was made in capturing, handling and transferring woodcock. Woodcock can be trapped and netted quite successfully, but cannot be held in small cages for long periods. Therefore, transportation over long distances was a problem. To overcome this obstacle the use of tranquilizing drugs was investigated.

Literature review showed that experiments with tranquilizing drugs (principally *Rauwolfia serpentina* alkaloids) had proven effective in other animals. However, most experiments were conducted on mammals, while little or no information was available on their effects on birds. Some work

HUNTING with a good dog insures hunters will recover downed birds.

was reported on pheasants by Hewitt (1957) and on wild turkey by Secord (1956). Secord, working with wild turkeys, found that a major difficulty in using serpasil was the apparent difference in tolerance of individual birds to the same dosage. It was also learned that although serpasil is virtually non-toxic to mammals, high dosages were lethal to birds.

This was found to be true for woodcock. Intramuscular injections of serpasil were administered to four woodcock within two hours of capture. The dosages were .08, .16, .25, and .50 mg/kg. No reaction was noticed with the two lower level dosages, but birds receiving the larger dosages were completely tranquil within one-half hour. The tranquilized woodcock died approximately eight hours after treatment. Birds on small dosages lived four days, during which time they consumed no food. The drug apparently interfered with the birds' desire and/or ability to eat even though no sedation was evident. On several occasions they picked up earthworms but never ingested any. Two additional controls (untreated woodcock) were released after six days. Except for some loss of weight they appeared unaffected.

In view of these experimental results and the difficulty in capturing additional woodcock, attention was directed to other bird species and types of drugs before returning to woodcock.

A series of tests was performed with the cooperation of the Pennsylvania State University Veterinary Science Department, Dr. R. F. Gentry, Veterinarian in charge of the Poultry Disease Research Laboratory, supervised the experiments. Six-week-old chickens were used for the first series of tests. The drugs used were thorazine, compazine, methylpromazine, sparine, and trilafon.

Thorazine When administered intramuscularly, thorazine began to show some effect at 40 mg/kg. Between 150 and 250 mg/kg, sedation took place but results were not constant. Some birds receiving 150 mg/kg became more tranquil than those receiving 250 mg/kg. Sedation usually occurred an hour after inoculation and lasted a maximum of eight hours. When the dosage was increased to 300 mg/kg sedation occurred in 10 to 15 minutes and lasted only 4 or 5 hours. At this level some toxic reaction resulted. At 500 mg/kg all birds died within the first hour.

Reaction to the drug varied with the route of administration. When administered orally no effect was evident even at dosages up to 500 mg/kg. But when given intravenously a toxic effect resulted at the comparatively low level of 50 mg/kg. No significant differences between responses to intramuscular and intraperitoneal administration were observed. In an attempt to prolong the period of sedation a group of domestic chicks was given a booster shot of thorazine and oil (50 mg/kg) an hour after receiving an initial inoculation of straight thorazine (100 mg/kg). This group became only slightly tranquil and recovered completely in three hours.

Compazine No response was observed in chicks inoculated with 10 to

40 mg/kg of compazine intramuscularly. Further tests were discontinued.

Methylpromazine At 100 mg/kg, only slight response was evident and at 150 mg/kg mild sedation occurred. Length of sedation was approximately 5 hours. Once again intramuscular inoculation was used.

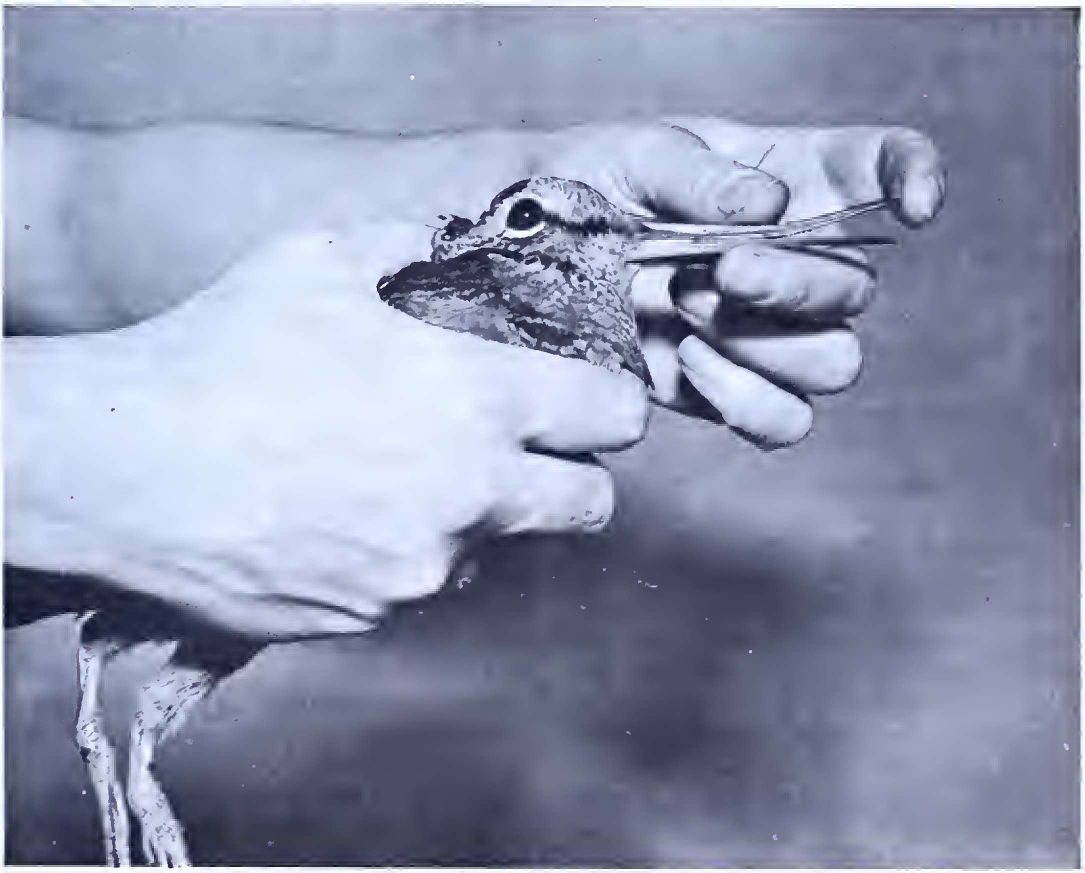
Sparine Methods of administration and results were very similar to that of methylpromazine.

Trilafon Trilafon appeared to act similarly to thorazine but perhaps somewhat better. Although no reaction was evident until dosages reached 80 mg/kg, additional tests showed that 160 mg/kg gave good results. At this level all chicks were tranquil within two hours and remained so for five hours. When booster shots of 50 mg/kg were given after 4 hours the sedation period was extended to 12 hours. Even after 24 hours the birds were still somewhat affected. When oil was added to the booster shot, the tranquil period was again slightly extended. These inoculations were administered intramuscularly.

Considerable mortality occurred when trilafon was given intraperitonealy at 200 mg/kg. Death probably resulted from a combination of two factors—(1) the absorption rate by this route was faster and (2) the chicks of this test group were younger (3 weeks) than those of the preceding group (6 weeks).

In summation, thorazine and trilafon apparently produce similar results. A desirable state of tranquility could be produced by either drug at dosage levels of 150 to 250 mg/kg when administered intramuscularly. The length of time of sedation varied

A WOODCOCK'S UPPER BILL is flexible, so it can probe for earthworms, insect larvae and other food items. Soils must be moist to provide the proper probing conditions.



THOUGH WOODCOCK usually lay four eggs in a clutch, two or three eggs are not uncommon and occasionally five eggs may be found in a nest.

from 5 to 15 hours, depending on whether or not a booster shot was given.

Later the most promising drugs were tested on bobwhite quail. Disappointingly but not unexpectedly, the quail reacted differently to the drugs than the chickens. Species variation in reaction is often extreme. With trilafon, via the intramuscular route, only slight sedation occurred at a dosage of 75 mg/kg. Some mortality was evident at this level. When the drug was given intraperitonealy, convulsions and deaths occurred at 50 mg/kg. Birds that recovered remained very tranquil for approximately three hours. Thorazine was even more toxic than trilafon. On the other hand, only slight response was observed from the same dosages of compazine and methylpromazine.

Experiments were then changed from tranquilizing drugs to a sedative-hypnotic drug called noludar. A new group of quail was acquired for another series of tests. Somewhat similar results were achieved with both the commercially prepared injectable noludar and with a supernatant solution obtained from dissolved noludar tablets. Quail were quickly put to sleep with dosages as low as 50 mg/kg. At 60 mg/kg they were comatose for 3 hours and at 130 mg/kg they slept for 5 hours. Increased initial dosage did not prolong sedation and toxic effect began to show up at approximately 200 mg/kg. On the other hand booster shots of 30 to 60 mg/kg every hour for 4 hours after an initial inoculation of 60 to 130 mg/kg increased the sedation time to about 8 hours. An inoculation of 130 mg/kg given to a single woodcock produced profound sedation for 10 hours. Unfortunately, more woodcock were not available for testing. It appeared that the sought after goal (12-15 hours sedation without ill effects) had almost been reached.

SUMMARY AND CONCLUSIONS

Seven different drugs were tested on four species of birds. Not only was there a marked difference in response to drugs between species, but also considerable variation in tolerance occurred between individuals of a species to constant dosages of the same drug. Trilafon and thorazine produced better results in chickens than did sparine, compazine and methylpromazine. Pigeons were not thoroughly tested due to the difficulty in evaluating their reactions. Quail showed considerable tolerance to the tranquilizers employed and the margin of safety was so small as to preclude their use. Noludar, on the other hand, produced long lasting sedation in quail with a wide margin of safety. Woodcock (single specimen) also responded very well to noludar. It appeared that the sedative-hypnotic drug noludar would satisfy the need for a safe, long lasting sedative better than any other drug tested.

This information was relayed to L. L. Glasgow at Louisiana State University to assist in preparing a group of woodcock for safe shipment to Pennsylvania. He experienced some success with noludar, but an accident and lack of assistance prevented completion of the experiment. In the meantime, Glasgow made progress in confining woodcock for long periods by mechanical measures.

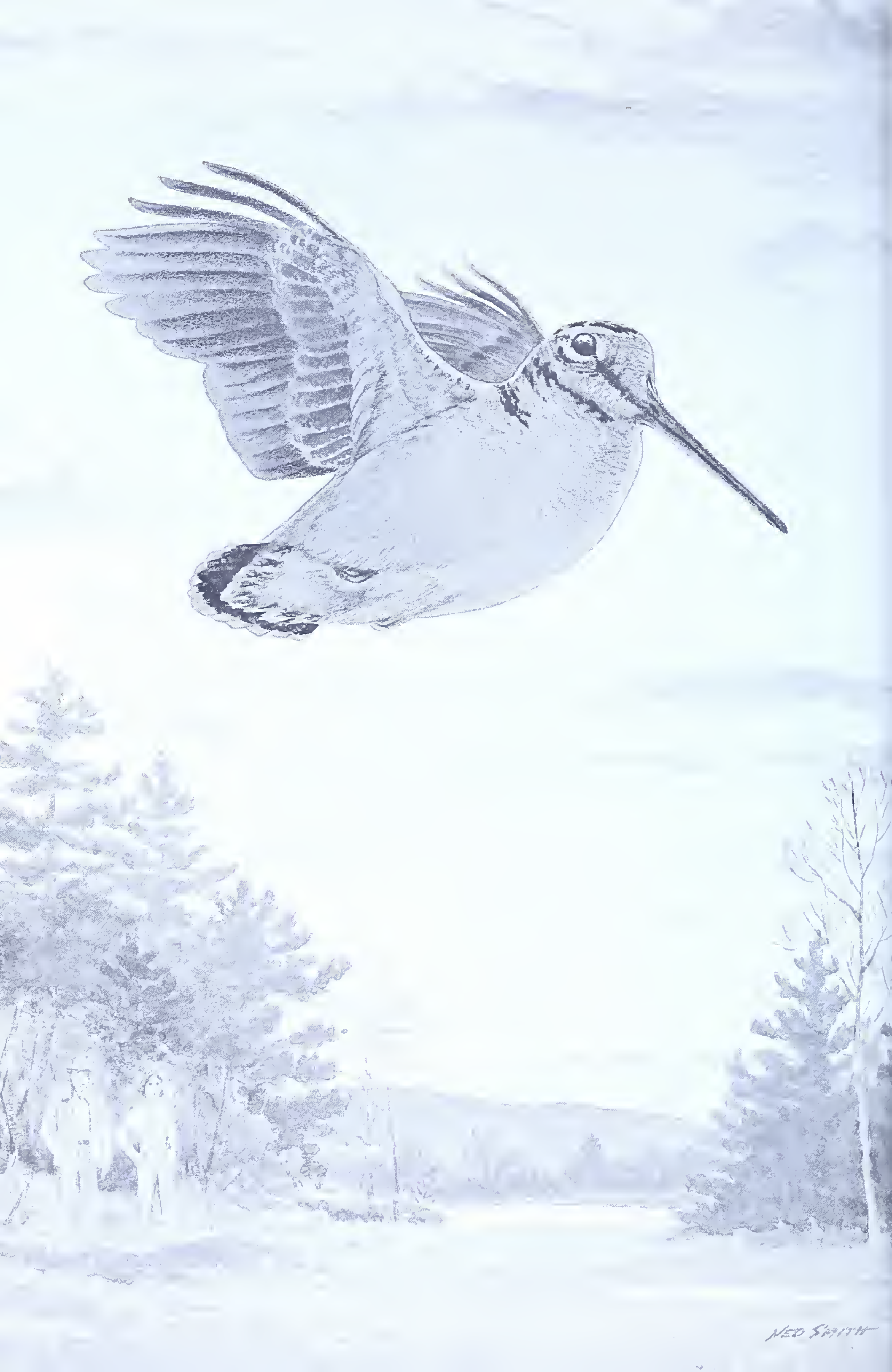
Education

Much can be done to improve the sport of woodcock hunting by a better understanding of the factors which limit woodcock populations. Sportsmen should be kept informed on the effect of habitat, hunting and other elements on this species. They should be encouraged to study woodcock habits in the field, and to create or maintain habitat when opportunity exists. Better decisions can certainly be made by better informed sportsmen. Bulletins such as this, informative press releases to newspaper outdoor columnists, and articles in magazines such as "Pennsylvania Game News" will increase public awareness of the woodcock's life history, research, management, sporting value and recreational potential.

DESPITE NEST PREDATION, it is doubtful if predator control measures would result in higher overall populations.

Predator Control

Greatest predation losses to woodcock occur at nesting time. Nevertheless, woodcock do experience high nesting success. Some benefit might accrue to woodcock by controlling raccoons, skunks, house cats, and great-horned owls where these predators are plentiful. Efforts could best be concentrated near good nesting areas. It is doubtful, however, that extensive control measures would result in a higher overall population.


NED SMITH

Recommendations and Summary

FINDINGS of the woodcock management study provided the following conclusions and recommendations.

Hunting Seasons

Woodcock hunting seasons in Pennsylvania should not begin before mid-October. A mid-October opening should allow the resident population to increase to near the carrying capacity of the available habitat. Some consideration should be given to opening seasons on other game (such as ruffed grouse and gray squirrel) at the same time or shortly after opening the woodcock season.

Habitat Management

Several practices for the creation and improvement of woodcock habitat were developed. The most promising involve planting, cutting and spraying. The following techniques should be incorporated in Game Lands management plans where suitable sites are available.

Emphasis in planting should be placed on alder propagation. This can be accomplished by transplanting seedlings or by direct seeding. Alder is by far the most important cover type in woodcock habitats.

Cutting tools and herbicides find greatest use in rejuvenating "worn out" coverts. The useful life of woodcock habitat is relatively short. Unless steps are taken to retard plant succession, many good coverts are lost. It is far easier to maintain good coverts than to create new ones. Methods are given in the text.

Management studies of species such as alder, hawthorn, aspen, gray dogwood and autumn olive and their relationship to woodcock should be encouraged and continued. Intimate knowledge of individual species is essential to management of the whole environment.

Habitat Acquisition

Good woodcock habitat in Pennsylvania is scarce, and we are fast losing what we have. This is especially true for lower slope and bottom land adjacent to streams. Many of these areas should be purchased for Game Lands and managed for woodcock and other game. Even tracts of several hundred acres would be worth acquiring for this purpose.

Inventories

Data on woodcock populations are needed to manage the species wisely. Therefore, cooperation with the U. S. Fish and Wildlife Service in its annual woodcock breeding ground census and the hunting season wing collection should be continued for the following reasons: (1) valuable data on trends in breeding population index and production have been acquired; (2) the techniques are the best known to date; and (3) there is a renewed interest in woodcock management. To aid the success of these inventories it is suggested that: (1) more intensive studies be conducted on woodcock behavior; (2) a coordinator be assigned in each interested state and province to record the status of the species; and (3) more incentive be offered cooperators, particularly those not employed by a conservation agency.

Education

Information pertaining to woodcock life history, population limiting factors, and management should be disseminated. This can be accomplished by the usual means of oral and visual communication.

OPENING WOODCOCK HUNTING SEASON along with the ruffed grouse and squirrel seasons is considered a valuable management tool. Good woodcock habitat is scarce and may be created by planting and improving available cover through cutting and spraying with herbicides.

Research Needs

Although considerable knowledge on woodcock management has been acquired, additional information is needed in the following areas:

1. How many people hunt woodcock either purposely or incidentally?
2. How many woodcock are harvested annually?
3. What percentage of the total bag consists of native woodcock?
4. What percentage of the total fall resident population does the harvest represent?
5. How many acres of woodcock habitat exist in the Commonwealth?
6. How accurately does the current breeding ground census reflect changes in population?
7. How can age data collected from wing surveys be used to greatest advantage?

SUMMARY

1. The Pennsylvania Woodcock Management Study was initiated in 1951 and concluded in 1961. Primary study areas were located in Centre, Huntingdon, Indiana, and Luzerne Counties.

2. The main objective was to determine whether the native woodcock population was declining and, if so, to develop management practices which would aid in its recovery. The project was aimed primarily at developing techniques of creating and improving

woodcock habitat, but it also became necessary to conduct limited studies on life history, ecology and populations.

3. The following pertinent data were acquired on woodcock life history:

(a) The fall migration peak occurs during the last week in October, while spring migration is complete by the first week in April.

(b) Nesting studies showed approximately 70 percent nesting success, a clutch size of 3.66 eggs, a brood size of 3.03 chicks, and an incubation period of 21 days. The hatching season peak occurs during the last week in April and the first week in May.

(c) Woodcock will eat a wider variety of food than was generally known and can subsist on approximately 3 ounces of earthworms daily. Observations on the manner of locating and ingesting food were recorded.

4. Factors which limit woodcock populations were:

(a) Reproductive capacity. The average ratio of immatures per adult during the hunting season was 1.01 to 1.00. With such a low reproductive rate and a short life expectancy a woodcock population does not increase rapidly.

(b) Habitat requirements. Woodcock habitat is rather well defined and specific in nature. Good woodcock habitat should contain (1) woody vegetation less than 30 years old, interspersed with small clearings; (2) an overstory of approximately 75 percent and a ground cover of about 25 percent; and (3) the soil beneath or near the covert should contain a rather constant supply of suitable food. Common and speckled alder were by far the most important plants occurring in woodcock habitat. Other important species included aspen, hawthorn and gray dogwood. An analysis of the primary cover types was presented.

(c) Hunting pressure. Hunting was important in limiting woodcock populations. Resident woodcock comprised more of the hunters' bag than was formerly known. This was especially true when seasons opened prior to mid-October, and where woodcock habitats were small and more or less isolated. Data were recorded on hunting success and the effect of gunning pressure.

HUNTING IS IMPORTANT in limiting woodcock populations. Opening the season after mid-October reduces pressure on resident populations.

5. The status of the woodcock population in Pennsylvania was discussed. It was evident that the woodcock harvest decreased from the 1930s to the 1950s. After 1950, however, the har-

BREEDING GROUND CENSUS and hunting season wing collection should be continued for wise management of the woodcock resource.

vest remained rather stable. More recent census and harvest data show a decrease from 1953 to 1956 and an increase from 1956 to 1961. Delaying the opening of the hunting season from early to mid-October is suggested as one reason for the increase.

6. A brief account follows of management practices tested and described in the report.

(a) Habitat manipulation. The basic principles of manipulating woodcock habitat by planting, cutting, spraying and grazing were discussed. Planting alder by transferring seedlings or by direct seeding was recommended for certain areas. Cutting was suggested for rejuvenating "worn out" coverts. Spraying with herbicides finds greatest use in conjunction with cutting to limit regrowth of unwanted species. Grazing was beneficial only when adequate controls could be exercised. The relationship of these procedures to specific cover types was described separately. A woodcock habitat management plan in actual use was presented.

(b) Hunting regulations. Study findings indicated that a mid-October season opening was appropriate for existing conditions. Earlier opening dates created excessive gunning pressure on the resident population. Other types of hunting regulations also were proposed to aid in species management.

(c) Other considerations. The roles of predator control, transplantation, and education also were discussed. These were considered to be of minor importance in woodcock management. However, an increased public awareness of the woodcock's value as a game species would help to stimulate greater interest in its management.

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Appendix A

Pennsylvania Game Commission　　Division of Research

Woodcock Hunter's Daily Record

Date .... Name ....

If recording individually—Number of hours *you* hunted ....

If recording by party—(a) Number of hours *party* hunted ....

(b) Number of hunters in party ....

Location, Cover, and Success of Day's Hunt

Hunting Area No.	County and Nearest Town	Number of Woodcock	*Predominant Cover Types*									
			Pure Alder	Pure Hawthorn—Crab Apple	Mixed Growth—Mostly Alder	Mixed Growth—Mostly Hawthorn—Crab Apple	Mixed Growth—Other	Aspen				
		Flushed—										
		Killed—										
		Flushed—										
		Killed—										
		Flushed—										
		Killed—										

Instructions

1. One member of the hunting party may record the results of the day's hunt or each member may record individually. Only one method should be used, to avoid duplication.
2. Try to avoid counting reflushes.
3. Keep a record even though no woodcock are flushed or killed during the hunt; simply mark zero (0) in the appropriate spaces.
4. Should you hunt in more than one location the same day, list each location and accompanying data on a separate line.
5. If you shoot a banded woodcock, record the leg band number on back of form and designate the location of the kill.
6. Return the completed forms to the address given below. Additional forms and information may be obtained from the same address.
7. All comments will be gratefully received. Notes concerning migratory flights or other movements will be especially helpful. Use back of form.

Thanks for your cooperation.—Steve Liscinsky, 623 S. Frazier St., State College, Pa.

Appendix B

Pennsylvania Game Commission — Division of Research

Field Data Sheet
(For Woodcock Habitat Studies)

Cover Type .... Area No. ....

Location .... Date ....

.... Time ....

Area use—past .... recent .... current ....

Physiography—altitude .... slope .... exposure ....

Soil Data

Texture .... O.M. ....

pH .... L.R. .... P. .... K. ....

Earthworm Data

	Soil Moisture	Percent Ground Cover	Surface Temperature	No.	Vol.	Worms No.	Worms Vol.	Species
1.								
2.								
3.								

Cover Data

Classification
Avg. Max.

Age ....
Ht. ....
Dia. ....
Vig. ....

Density

Size plot ....
No. clumps/plot ....
Tot. stems/clumps ....
Avg. stems/clump ....
Tot. single stems ....
Tot. stems/plot ....
No. stems/acre ....

Sample Stems

	Age	Ht.	Dia.
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Woody Species

	Spp.	% Cover
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

Non-Woody Species

	Spp.	% Cover
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Non-Woody Species

	Spp.	% Cover
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		
19.		
20.		
21.		
22.		
23.		
24.		
25.		
26.		
27.		
28.		
29.		
30.		

Comments: Use other side.

Appendix C

Trees And Shrubs

Alder	*Alnus serrulata*
Apple	*Pyrus spp.*
Arrow-wood	
Black-haw	*Vibernum prunifolium*
Southern Arrow-wood,	*Vibernum deutatum*
Ash, White	*Fraxinus americana*
Aspen	*Populus spp.*
Beech, Blue	*Carpinus caroliniana*
Birch, Black	*Betula lenta*
Blackberry	*Rubus spp.*
Black-haw Viburnum,	*Vibernum prunifolium*
Blueberry	*Vaccinium sp.*
Cherry	
Black	*Prunus serotina*
Choke	*Prunus virginiana*
Chokecherry	*Pyrus sp.*
Deerberry	*Vaccinium stamineum*
Dewberry	*Rubus sp.*
Dogwood	
Flowering	*Cornus florida*
Gray	*Cornus racemosa*
Silky	*Cornus Amomum*
Elder, Common	*Sambucus canadensis*
Elderberry	*Sambucus canadensis*
Elm, American	*Ulmus americana*
Grape	*Vitis spp.*
Hawthorn	*Crataegus spp.*
Hazlenut, American	*Corylus americana*
Hemlock	*Tsuga canadensis*
Hickory	*Carya sp.*
Juneberry	*Amelanchier sp.*
Larch	*Larix sp.*
Locust	*Robinia Pseudo-Acacia*
Maple	
Red	*Acer rubrum*
Sugar	*Acer saccharum*
Ninebark	*Physocarpus opulifolius*
Oaks	
Red	*Quercus rubra*
Scrub	*Quercus ilicifolia*
Pines	
Banks	*Pinus Banksiana*
Pitch	*Pinus rigida*
Red	*Pinus resinosa*
Table Mountain	*Pinus pungens*
White	*Pinus Strobus*
Plum	
Allegheny	*Prunus allegheniensis*
Wild	*Prunus americana*
Poison Ivy	*Rhus radicans*
Poplar, tulip	*Liriodendron Tulipifera*
Raspberry	*Rubus sp.*
Rose	*Rosa spp.*
Sassafras	*Sassafras albidum*
Shadbush	*Amelanchier sp.*
Spicebush	*Lindera Benzoin*
Spiraea	*Spiraea sp.*
Spruce	*Picea sp.*
Sumac, Smooth	*Rhus glabra*
Virginia Creeper,	*Parthenocissus quinquefolia*
Viburnum	*Viburnum spp.*
Virgin's Bower	*Clematis virginiana*
Walnut, Black	*Juglans nigra*
Willow	*Salix sp.*
Witch-hazel	*Hamamelis virginiana*

Herbs

Arrow-Leaved Tearthumb,	*Polygonum saggittatum*
Artichoke, Jerusalem	*Helianthus tuberosus*
Aster	*Aster sp.*
Avens	*Geum canadense*
Bedstraw, Rough	*Galium asprellum*
Bellwort	*Oakesia sessilifolia*
Bindweed, Black	*Polygonum convolvulus*
Black-eyed Susan	*Rudbeckia serotina*
Black Snakeroot	*Cimicifuga americana*
Bloodroot	*Sanguinaria canadensis*
Bluets	*Houstonia caerulea*
Boneset	*Eupatorium perfoliatum*
Cinquefoil	*Potentilla canadensis*
Club-moss	*Lycopodium spp.*
Dock	*Rumex sp.*
Dogbane	*Apocynum sp.*
Everlasting	*Antennaria spp.*
Fern	
Bracken	*Pteridium latiusculum*
Christmas	*Polystichum arcrostichoides*
Grape	*Botrychium obliquum*
Marginal Shield	*Dryopteris marginalis*
Sensitive	*Onoclea sensibilis*
Woodsia	*Woodsia obtusa*
Fleabane, Daisy	*Erigeron strigosus*
Geranium	*Geranium spp.*
Golden Ragwort	*Senecio aureus*
Goldenrod (1)	*Solidago rugosa*
Goldenrod (2)	*Solidago graminifolia*
Goldenrod (3)	*Solidago juncea*
Grass	
Bluegrass	*Poa spp.*

Poverty	*Danthonia spicata*
Panic	*Panicum spp.*
Hawkweed	*Hieracium sp.*
Heal-all	*Prunella vulgaris*
Hemlock, Water	*Cicuta sp.*
Horsetail	*Equisetum spp.*
Ironweed	*Vernonia sp.*
Jack-in-the-Pulpit	*Arisaema triphyllum*
Jewelweed	*Impatiens spp.*
Joe-Pye-weed	*Eupatorium dubium*
Mallow	*Malva sp.*
May-apple	*Podophyllum peltatum*
Milkweed	*Asclepias spp.*
Mint, Wild	*Mentha arvensis*
Moss	
Common	*Commelina spp.*
Club	*Lycopodium spp.*
Hair-Cap	
Sphagnum	
Motherwort	*Leonurus cardiaca*
Onion, Wild	*Allium cernuum*
Pennywort	*Obolaria virginica*
Plantain	*Plantago sp.*
Polygala, Fringed	*Polygala paucifolia*
Ragweed	*Ambrosia trifida*

Rose	*Rosa spp.*
Rue-Anemone	*Anemonella thalictroides*
Sedge	*Cyperaceae sp.*
Skunk Cabbage	*Symplocarpus foetidus*
Smartweed	*Polygonum sp.*
Sorrel, Sheep	*Rumex Acetosella*
Sorrel, Wood	*Oxalis corniculata*
Speedwell, Common	*Vernonica officinalis*
Sweet-fern	*Comptonia sp.*
St. John's-wort	*Hypericum spp.*
Strawberry	*Fragaria virginiana*
Barren	*Waldsteinia fragarioides*
Tall-Meadow-Rue	*Thalictrum polygamum*
Teaberry	*Gaultheria procumbens*
Thistle, Canada	*Cirsium arvense*
Timothy	*Phleum spp.*
Thimbleweed	*Anemone cylindrica*
Turk's-cap-Lily	*Lilium superbum*
Turtlehead	*Chelone sp.*
Vervain, Blue	*Verbena hastata*
Violet	*Viola sp.*
Virginia Creeper	*Parthenocissus sp.*
Whorled Loosestrife,	*Lysimachia quadrifolia*
Wild Carrot	*Daucus carota*
Woodrush	*Luzula spp.*
Wood-Sorrel	*Oxalis corniculata*
Yarrow, Common	*Achillea Millefolium*
Yellow Dock	*Rumex crispus*

Appendix D

Woodcock Captured and Banded in Pennsylvania (1939 to 1960)

Date of Capture	Band Number	Place of Capture*	Method of Capture**	Sex	Age
4/13/39	425003	14-8	2		
4/17/39	425001	14-8	2		
4/19/39	425006	14-8	2		
4/25/39	425005	14-8	2		
4/27/39	425004	14-8	2		
4/28/39	425008	14-8	2		
4/29/39	425009	14-8	2		
5/3/39	425010	14-8	2		
5/4/39	425007	14-8	2		
5/8/39	425015	14-8	2		
5/8/39	425016	14-8	2		
5/8/39	425017	14-8	2		
5/8/39	425018	14-8	2		
5/10/39	425014	14-8	2		
5/10/39	425013	14-8	2		
5/11/39	425019	14-8	2		
5/17/39	425023	14-8	2		
5/17/39	425022	14-8	2		
4/4/40	39-425039	31-1			
4/5/40	39-425035	31-1			
4/8/40	39-425044	14-8	2		
4/10/40	39-425043	14-8	2		
4/11/40	39-425026	14-8	2		
4/14/40	39-425033	14-8	2		
4/18/40	39-425031	14-8	2		
4/28/40	39-425045	14-8	2		
4/2/40	39-425046	14-8	2		
4/2/40	39-425042	14-8	2		
4/8/41	41-304495	14-8	2		
4/11/41	41-304500	14-8	2		
4/16/41	41-304498	31-1	2		
4/13/41	41-408935	14-8			
4/13/41	41-408955	14-8			
4/23/42	41-304463	22-1			
4/25/42	41-304491	14-8			
7/3/52	513-83301	14-1	3		
7/17/52	513-83302	14-3	3		
7/24/52	513-83303	14-3	3		
7/27/52	513-83304	14-3	3		
7/27/52	513-83305	14-3	3		
8/1/52	513-83306	14-3	3	F	
8/2/52	513-83307	14-3	3	F	
8/4/52	513-83308	14-3	3	M	
8/7/52	513-83309	14-3	3	M	
8/8/52	513-83310	14-3	3		
8/10/52	513-83311	14-3	3	F	
8/10/52	513-83312	14-3	3	M	
10/11/52	513-83321	14-1	3	M	
10/25/52	513-83322	14-1	3		
11/4/52	513-83323	14-1	3	F	
4/20/53	513-83324	14-2	1		J
4/20/53	513-83325	14-2	1		J
4/20/53	513-83326	14-2	1		J
4/20/53	513-83327	14-2	1		J
4/28/53	513-83328	14-4	1		J
4/28/53	513-83335	14-4	1		J
4/28/53	513-83329	14-4	1		J
4/28/53	513-83344	14-4	1		J
4/28/53	513-83330	14-4	1		J
4/28/53	513-83332	14-4	1		J
4/28/53	513-83333	14-4	1		J
4/28/53	513-83342	14-4	1		J
4/28/53	513-83343	14-4	1		J
4/28/53	513-83345	14-4	1		J
4/29/53	513-83337	14-2	1		J
4/29/53	513-83331	14-2	1		J
4/29/53	513-83334	14-2	1		J
4/29/53	513-83341	14-2	1		J
4/29/53	513-83329	14-2	1		J
4/29/53	513-83336	14-2	1		J
4/29/53	513-83340	14-2	1		J
4/29/53	513-83346	14-2	1		J
4/29/53	513-83347	14-2	1		J
4/29/53	513-83349	14-2	2	M	A
5/8/53	513-83350	14-4	1		J
5/21/53	513-83356	14-7	1		J
7/9/53	513-83338	14-3	3		
7/13/53	513-83348	14-3	3		
7/22/53	513-83351	14-2	3		
7/28/53	513-83352	14-2	3		
7/29/53	513-83353	14-2	3		
7/31/53	513-83354	14-3	3		
8/5/53	513-83355	14-2	3	M	
8/6/53	513-83357	14-2	3	F	
8/7/53	513-83359	14-2	3		
8/11/53	513-83358	14-2	3	M	
8/20/53	513-83360	14-2	3		
8/22/53	513-83361	14-2	3	M	
8/24/53	513-83362	14-2	3	F	
8/24/53	513-83363	14-2	3	F	
8/28/53	513-83364	14-2	3		
9/27/53	513-83365	14-2	3	M	
9/28/53	513-83366	14-2	3	F	
9/29/53	513-83367	14-2	3	F	
10/2/53	513-83368	14-2	3	M	
10/4/53	513-83369	14-2	3	F	
10/6/53	513-83370	14-2	3	M	
10/9/53	513-83371	14-2	3	F	
10/9/53	513-83372	14-2	3	M	
10/11/53	513-83373	14-2	3	M	
11/1/53	513-83374	14-2	3	M	
11/2/53	513-83375	14-2	3		
11/5/53	513-83376	14-2	3		
11/10/53	513-83377	14-2	3	F	
11/11/53	513-83378	14-2	3	M	
11/20/53	513-83379	14-2	3	M	
4/17/54	513-83381	14-3	2	M	A
4/19/54	513-83382	14-3	4	F	A

Date of Capture	Band Number	Place of Capture*	Method of Capture**	Sex	Age
4/20/54	513-83383	14-3	2	M	A
4/21/54	513-83384	14-3	1		J
4/21/54	513-83385	14-3	1		J
4/21/54	513-83386	14-3	1		J
4/21/54	513-83387	14-3	1		J
4/27/54	513-83388	14-4	1		J
4/27/54	513-83389	14-4	1		J
4/27/54	513-83390	14-4	1		J
4/27/54	513-83391	14-4	1		J
4/27/54	513-83392	14-4	1		J
4/27/54	513-83393	14-4	1		J
4/27/54	513-83394	14-4	1		J
4/30/54	513-83397	14-4	1		J
4/30/54	513-83398	14-4	1		J
5/7/54	553-39011	31-1	1		J
5/7/54	553-39012	31-1	1		J
5/12/54	553-39013	14-6	1		J
5/15/54	553-39017	31-1	1		J
6/29/54	553-39031	14-2	3		
7/2/54	553-39022	14-2	3		
7/13/54	513-83395	14-2	3		
7/13/54	513-83396	14-2	3		
7/14/54	513-83399	14-2	3		
7/27/54	513-83400	14-1	3		
7/27/54	553-39001	14-2	3		
7/27/54	553-39002	14-2	3		
7/27/54	553-39003	14-3	3		
7/29/54	553-39004	14-3	3		
7/31/54	553-39005	14-2	3		
8/2/54	553-39006	14-3	3		
10/1/54	553-39007	14-2	3		
10/9/54	553-39008	14-2	3		
4/1/55	553-39009	14-3	4	M	A
4/6/55	553-39033	31-1	4	M	A
4/6/55	553-39034	31-1	4	M	A
4/7/55	553-39035	14-4	1		
4/7/55	553-39036	14-4	1		
4/7/55	553-39037	14-4	1		
4/7/55	553-39038	14-4	1		
4/11/55	553-39051	14-3	1		
4/11/55	553-39052	14-3	1		
4/11/55	553-39053	14-3	1		
4/23/55	553-39039	31-1	1		
4/26/55	553-39040	14-6	1		
4/26/55	553-39041	14-4	1		
4/27/55	553-39042	14-2	1		
4/27/55	553-39043	14-2	1		
4/30/55	553-39061	14-5	1		J
4/30/55	553-39062	14-5	1		J
4/30/55	553-39063	14-5	1		J
4/30/55	553-39064	14-5	1		J
5/3/55	553-39065	31-1	1		J
5/3/55	553-39066	31-1	1		J
5/3/55	553-39067	31-1	1		J
5/14/55	553-39068	14-6	1		J
5/14/55	553-39069	14-6	1		J
5/14/55	553-39070	14-6	1		J
5/14/55	553-39071	14-6	1		J
7/6/55	553-39026	14-2	3		
7/12/55	553-39044	14-3	3		
7/15/55	553-39045	14-2	3		
7/18/55	553-39046	14-2	3		
7/18/55	553-39047	14-2	3		
7/12/55	553-39048	14-3	3		
7/21/55	553-39049	14-3	3		
7/22/55	553-39050	14-3	3		
7/26/55	553-39010	14-2	3		
8/2/55	553-39015	14-2	3	M	
8/3/55	553-39016	14-3	3	F	
8/3/55	553-39018	14-2	3	M	
8/3/55	553-19019	14-2	3	M	
8/7/55	553-39020	14-2	3	F	
8/10/55	553-39021	14-2	3	M	
8/10/55	553-39022	14-3	3	F	
9/14/55	553-39024	14-3	3	F	
9/15/55	553-39025	14-2	3	F	
9/21/55	553-39027	14-2	3	F	
9/23/55	553-39029	14-3	3	M	
9/23/55	553-39030	14-3	3	F	
4/20/56	553-39072	14-3	1		J
4/20/56	553-39073	14-3	1		J
4/20/56	553-39074	14-3	1		J
4/27/56	553-39085	14-4	4	F	A
4/30/56	553-39086	14-5	1		J
4/30/56	553-39087	14-5	1		J
4/30/56	553-39088	14-5	1		J
7/29/56	553-39028	14-3	3		
8/2/56	553-39054	14-3	3	F	

Key to Pennsylvania Woodcock Banding Records

**Capture Locations*

County	*County No.*	*Locale*
Centre	14	1. Unionville
Centre	14	2. Julian
Centre	14	3. Martha Furnace
Centre	14	4. Port Matilda
Centre	14	5. Hannah
Centre	14	6. Bald Eagle
Centre	14	7. Phillipsburg
Centre	14	8. Scotia
Huntingdon	31	1. Charter Oak
Dauphin	22	1. Harrisburg

***Capture Methods*

1. Chicks found with aid of bird dogs.
2. Butterfly clap-type trap on singing grounds.
3. Modified shore bird-type funnel trap.
4. Long handled net, with or without headlight.

Note: Woodcock banded prior to 1952 by L. J. Bennett, A. T. Studholme, R. T. Norris, and J. D. Beule.

Date of Capture	Band Number	Place of Capture*	Method of Capture**	Sex	Age
5/12/57	553-39111	14-8	2	M	A
5/14/57	553-39112	14-2	1		J
5/24/57	553-39141	31-1	4	F	A
7/15/57	553-39056	14-2	3		
7/16/57	553-39058	14-2	3		
7/23/57	553-39060	14-2	3		
7/24/57	553-39113	14-2	3		
7/26/57	553-39114	14-2	3		
7/31/57	553-39115	14-2	3		
7/31/57	553-39116	14-2	3		
8/12/57	553-39119	14-2	3		
8/13/57	553-39120	14-2	3		
5/3/58	553-39121	14-3	1		J
5/3/58	553-39122	14-3	1		J
5/3/58	553-39123	14-3	1		J
5/12/58	553-39124	14-4	1		J
5/12/58	553-39125	14-4	1		J
5/12/58	553-39126	14-4	1		J
6/16/58	553-39127	31-1	1		J
6/16/58	553-39128	31-1	1		J
6/16/58	553-39129	31-1	1		J
7/30/58	553-39153	14-8	3		
5/1/59	553-39156	14-6	1		J
5/1/59	553-39157	14-6	1		J
5/1/59	553-39158	14-6	1		J
5/1/59	553-39159	14-6	1		J
5/1/59	553-39160	14-6	1		J
5/2/59	553-39161	14-4	1		J
5/2/59	553-39162	14-4	1		J
5/2/59	553-39163	14-4	1		J
5/8/59	553-39151	31-1	1		J
5/8/59	553-39154	31-1	1		J
5/8/58	553-39155	31-1	1		J
9/20/59	553-39152	31-1	3		
5/7/60	553-39075	14-4	1		J
5/7/60	553-39076	14-4	1		J
5/7/60	553-39077	14-4	1		J
5/7/60	553-39078	14-4	1		J
8/29/60	553-39164	31-1	3		
9/1/60	553-39079	31-1	3	F	
9/1/60	553-39080	31-1	3	M	
9/3/60	553-39081	31-1	3	M	

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Appendix E

HUNTERS PLEASE NOTICE

Experimental Woodcock Area

This area has been closed to woodcock hunting this season to permit recovery of the native woodcock population. Please cooperate. Shooting of other kinds of game is permitted.

The Pennsylvania Game Commission
Division of Research

Commonwealth of Pennsylvania

MILTON J. SHAPP, GOVERNOR

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